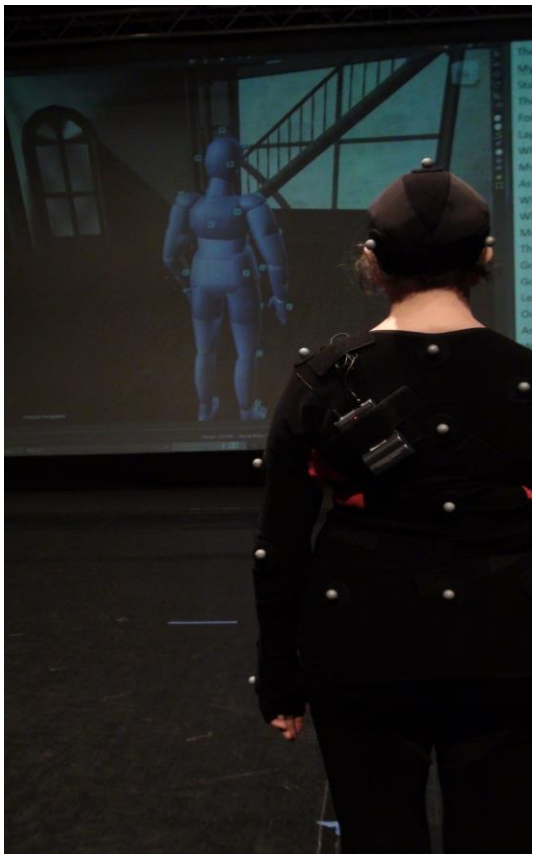
The Cooling Steam of The Polar Express:
Historical origins, properties and implications of Performance Capture



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Abstract

This practice-based research explores the historical origins, properties and implications of the development of performance capture. It identifies and frames the relationships between the performer, the system and the operator of a motion capture system, and establishes five domains of understanding informed by a body of historical and theoretical discourse. These domains are: motion capture Infrastructure and Workflow; the Language of performance capture; Spatial Framing and Feedback; Tool Use and Time; and the Environmental Navigation of Physical and Virtual Space. This research provides a framework for the first academically rigorous interrogation of the generation of performance within the global frame of the motion capture volume. It develops and tests a set of first principles through an original series of theoretically informed, practical exercises to guide those working in this emergent space. This initiates and positions performance capture as a new and distinct interdisciplinary discourse in the fields of theatre, animation, performance studies and film.

Statement of Original Authorship

The work contained in this document has not been previously submitted to meet the requirements for an award at this or any other higher education institution. It should be noted that some of the work contained was previously used and submitted in a successful confirmation seminar and viva in a prior PhD enrolment at Queen Mary University of London, this PhD enrolment has been transferred to the Queensland University of Technology. To the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made.

QUT Verified Signature

Signed:..

Name: Matt Delbridge

Date: May 2014

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Key words: actor training, digital performance, digital scenography, motion capture, intermediality, performance capture, film production, animation, practice-based research

Abbreviations:

SAA	shakespearean actor avatar
NAA	neutral actor avatar
PeCap	performance capture
MoCap	motion capture
IoP	illustration of practice
CGI	computer generated imagery

Definition of terms

These definitions are drawn from the OED and adapted for the relevance to the research.

Capture Volume

Within the parameters of this study, a capture volume is the amount of space that the motion capture system can 'see' and performance can be recorded within.

Ecology

The OED provides a range of focused definitions of the term 'ecology'. The following three have been selected as they most closely inform this research. They are: the branch of biology concerned with relationships between living organisms and their environment and their relationships themselves; the study of relationships between people, social groups and their environment; and the interrelationship between any system and its environment. A combination of these definitions is significant in the consideration of the navigation and visual perception of environs in an ecological frame.

Infrastructure

Determined as physical and organisational structures and facilities necessary for the operation of a society or enterprise. Performance captured in a motion capture space requires equipment and 'organisational structures' (the human, data, equipment and capture management systems) to facilitate the processes, production and capture of performance. This study reconceptualises significant components of the prescribed requirements for motion capture projects and makes infrastructural suggestions that better enable a performance capture shoot.

Motion Capture

A filmmaking technique where actors wear specially designed suits allowing computers to track their movements, which are used as the basis for lifelike animated characterisation.

Performance Capture

A term first employed by the director/producer Robert Zemeckis during the Warner Bros production of *The Polar Express* (2004). It is used to describe the total recording of a performance without cuts using a motion capture system. Performance capture sees an entire performance captured in one take, allowing traditional framing questions and dramatic devices to be employed post-performance.

Techné

Art, skills or craft, including techniques, principles and methods by which a work, product or performance is achieved or created.

Time

Within the parameters of this study, time is a finite stretch of continued existence, the interval separating two successive events or actions, or the period during which an action, condition or state continues. In terms of duration, it is regarded as that in which the sequence of events takes place.

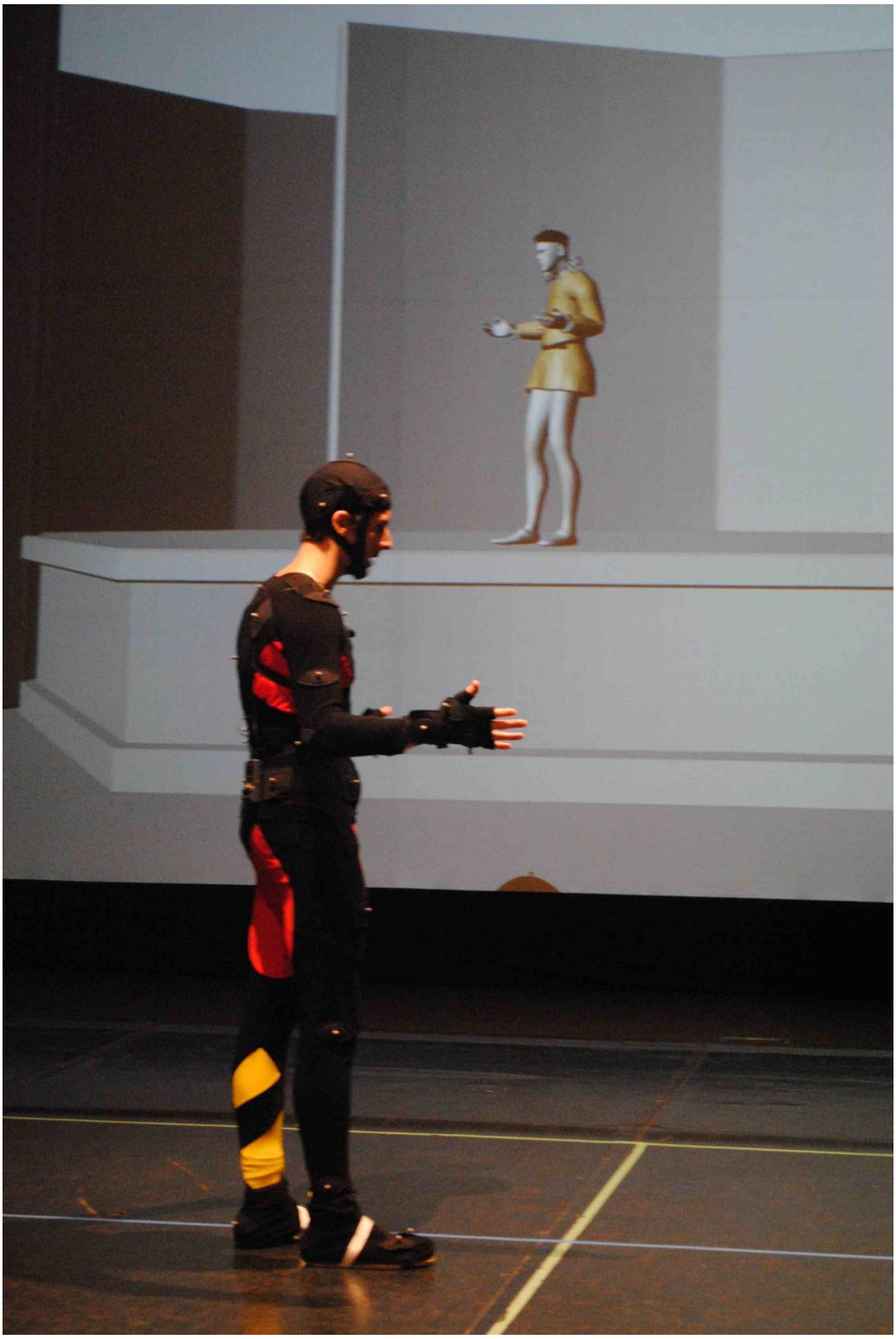

Fig 1: Lachlan Woods Driving Shakespearean Actor Avatar (SAA), Deakin Motion.Lab workshops 2010/11
(Image M Delbridge 2011)

Introduction

Turning on the lights

In 1991, I stood on a platform behind a portable seating bank installed in Town Hall Motors, in Carlisle Street, St. Kilda.[1] *The Dybukk*, Gilgul Theatre Company's first production, was about to open. A bomb threat had sidetracked Rob Lehrer, the lighting designer and Gilgul's general manager, and I was to operate an LSC 60/120 preset desk, a lighting console the size of a grand piano.[2] I'd never operated a lighting console before. Like Barry Kosky's piano beside me, this manual desk had to be played.[3] The show began, and my life changed forever.

I had joined the company three months prior. I was the director's assistant, then became the stage manager (when they realised that they didn't have one), and on opening night found myself behind the LSC. I stage managed and operated the lights for every Gilgul performance for the next eight years and always sat next to Barry, playing the lighting console in synch to his piano. I was an operator, and became a good one.

Fifteen years later, I found myself in a reclaimed theatre space at Deakin University sitting in front of three computer workstations, a 24 camera Motion Analysis optical motion capture system and two dancers dressed in lycra Velcro suits sprinkled with 50 retro reflective markers each. Jeff Thingvold from Motion Analysis, the trainer brought from the United States to teach us the system, discussed ophthalmological triangles like we were supposed to know what they were. About to drive an AU$500,000 motion capture system for the first time, I was struck with the same inadequacies of that opening night of *The Dybukk* (1991).

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[1] Town Hall Motors was an abandoned Auto Garage opposite the St Kilda Town Hall in Victoria, Australia. It was loaned to Gilgul Theatre Company by the owner to be used as a theatre space for *The Dybukk* (seasons 1 and 2) and *Es Brent*. It is now a nail salon.

[2] The LSC 60/120 was an analogue lighting console with 60 to 120 individual channels that can be operated in preset or wide mode i.e.: either two scenes set at any one time – preset 2 x 60 channels, wide 120 channels. It's as long as a short surfboard.

[3] Barry Kosky is currently the Artistic Director, Komische Oper, Berlin

Every operator fears a mistake. It's one of two things: letting somebody down or looking foolish. A good operator will make a lasting connection to the work they are a part of and the people they are working with (and for), so if either happens, the performance goes unhindered. The operator's role is often misunderstood as a function in the process. It is certainly a good deal more than the pressing of a button or the turning of a handle; the role is crucial to, and central in, the execution of live and captured performance. Renewing this understanding sits at the heart of this research. While the study primarily considers and redefines what we know as motion and performance capture, it is the operator, the technical director and what we will come to think of as the performance capture director's roles that are core to shaping this understanding.

In the period between 2006 and 2009, the Australian dollar grew so strong the country's industry for console games all but disappeared. Surprisingly this didn't mean commercial activity in the field ceased.[4] In fact, developer activity increased through the incorporation of motion capture into their games, except that developers had little to no experience in motion capture. Appointed to the Deakin Motion.Lab in 2006, I experienced the fiery baptism of the intricacies of motion capture (and 3D animation), the politics of the commercial games industry and the institutional pressures of a funded university research facility. I arrived at motion capture with a twenty-year professional background in theatre and film, working in a range of capacities and environments. My training, which was for the most part informal and learnt on the stage, was a unique preparation for running a motion capture studio where most normally come from a film or animation background.

[4] The volatility of the Australian dollar has a significant impact on small to medium size industries, particularly when they are reliant on either: a) Australian Labor, b) Overseas export. Australia's gaming and film industries have always maintained a reliance on the American market. As the dollar here strengthens, the large multinational companies shift to cheaper economies.

What is performance capture?

This study considers the place and function of motion capture (MoCap) as a tool for capturing performance and seeks to examine and illuminate a deeper understanding of a cognate idea and practice – performance capture. MoCap has become an increasingly popular tool used in the generation of content for the animation and film industries in recent years. The processes central to generating performance using motion capture (i.e. performance capture) are under scrutinised and require anchoring as a mode of production. This study demonstrates a rigorous historical and theoretical discourse informs this practice, and that the identification and isolation of this assists in the definition of performance capture (PeCap).

A term often used in industry to describe aspects of performance captured using a MoCap system, PeCap remains mostly absent in literature and is not covered in formal studies available in our academies and institutions. Uncovering what happens in the act of generating performance in a motion capture studio reveals that there are unique production processes at play. The theorisation and firming of the practice of PeCap highlights the hybridity of this mode of production. These processes contribute to testing the meaning of recording live performance at the pinnacle of our understanding of visual perception, tool use, time, space, language and studio infrastructures. A key contribution of this study is located in unpacking this meaning. The development of a contemporary and pragmatic approach to the recording of performance is informed by this renewed and refined understanding.

Devising a contemporary context for the working principles of performance capture is central to this research. The term, first employed by the director/producer Robert Zemeckis during the Warner Bros production of *The Polar Express* (2004), was used to describe the total recording of a performance without cuts using a motion capture system. While at first glance this seems like a relatively simple concept, I assert that it is much more complicated. PeCap is

inherently theatrical, allowing an entire performance to be captured in one take, which significantly eliminates the need for multiple takes (of a single scene) to be recorded. This facility eases frame selection in the generation of content and allows editing to be completed after the act. In a sense, returning the methods of traditional filmmaking to the stage. It is important to note that this is a primary distinction from traditional filmmaking in that the theatrical approach to performance (central to PeCap) allows for the exploration and capture of a whole scene to be undertaken in real time unhindered by device limitations (like the frame). The freedom PeCap allows is clear of the traditional hurdles encountered in the profilmic set up and continuity of film production. It abandons the onerous repetition required for the ongoing reset and reframing of physical environments, enabling performance to occur and its inherent theatricality to re-emerge. It should be noted that many animation enthusiasts tend to look with disdain at the work of Zemeckis, claiming that performance capture diminishes the role of the animator (Hayes and Webster 2013). While this may be the case, an interrogation of this notion is outside the scope of this study. We need to acknowledge that there is a relationship between animator and performer in PeCap and that without the work of animators there would be no environment for performers to act within or characters for them to drive, but this is to be explored in future research projects.

Fig 2: Still from *The Polar Express* (Zemeckis, 2004)

Understanding performance capture as an interdisciplinary approach for capturing all modes of performance, including its first authoritive and rigorous definition, is a primary goal of this study. While the term is often used in industry in a variety of contexts, in this thesis I argue that PeCap will become a primary mode of generating and capturing performance into the future (beyond gaming and film) and that there is an imperative to establish working principles to allow this to occur. This study is the first of its kind and makes a major contribution to the historical, theoretical and practical discourse of this emerging field. The reappropriation of performance capture is not just for use throughout this thesis; it is reclaimed as a transformational force to extend our understanding of MoCap. This grounded (re)understanding is cumulatively developed as the world of the MoCap studio is revealed and a carefully selected body of appropriate theory and practice is applied to the action of the capture environment.

To begin a discourse for PeCap, the direction, operation and execution of performance in the motion capture studio requires a focused and disciplined approach that is able to make a meaningful contribution to the discourse of digitally mediated performance. Through the act of physically placing operators and performers into PeCap scenarios (and directing them), this study uncovers the nexus between the bodies of theory around performing for, and through, devices alongside a methodology that privileges practice. This has revealed a set of guidelines for working with a motion capture system in performance capture. There is a strict point of departure between the two terms MoCap and PeCap, and the distinction between these two is reasserted throughout the document. For the purpose of this study I define motion capture as the capture of movement for a given purpose facilitated by an input motion system. This broad definition comes from many sources, including Kitagawa and Windsor (2008), Liverman (2004) and Hayes and Webster (2013). The movement captured may be used for the animated actions of game play or for medical and sports science analysis (Hayes and Webster 2013). Performance capture is much more than this. It incorporates the pragmatic elements of MoCap, but demands a much closer

relationship between all of the participants in the studio and a mode of performance that maintains a sense of theatricality. It places a strong emphasis on the relationship between operator and performer, and demands that performers are completely initiated into the system in a conscious and deliberate manner before performance is captured. This renewed understanding of these terms contributes to existing discourses around preparing creative practitioners and technicians for entry into these environments, and sets the scene for a new and interdisciplinary form of generating creative content and performance that will take new prominence in our academies, institutions and production studios.

This study contributes a new term to the lexicon of performance studies, animation, film and PeCap called *The Omniscient Frame* (Delbridge 2012), first introduced in two earlier publications. The first in a book chapter co-authored with Joanne Tompkins, *Reproduction, mediation, and experience: virtual reality, motion capture and early modern theatre* in *Space–Event-Agency–Experience,* (2012). The second in a journal article *The ecological approach to visual perception and the actor performance captured in the gaming landscape* in *Animation Practice, Process and Production*, (2012). This revitalized notion of framing is discussed in detail in Chapter Three *Space and the Frame*, but in short establishes a revolutionary approach to performance in MoCap that acknowledges the global nature of performance captured using an optical MoCap system.

While this research contributes to broader bodies of scholarship in scenographic theory, digital performance, film, technology studies, actor training and animation, its primary contribution is to the scholarship of motion capture. It interrogates the role of operators, directors, designers, animators and performers through focused practical work with performers and technicians, using a MoCap system to generate a PeCap'd performance. Additionally, the study provides a critical perspective on current trends in performance theory. The most significant of these is the documentation of live performance. While an in-depth discussion of

the preservation of the live performance is beyond the scope of this study, the relocation of the capture of performance from the periphery to the centre, or the documentation of the live with liveness, opens the potential for future research to be undertaken.[5]

Research Problem

The body of theory available, while providing a historical and contemporary perspective on space and its navigation, does not offer the necessary focus on dilemmas associated with simultaneous performance in the spatial binary of the physical and the virtual in motion capture. In this thesis, this tension is primarily explored in the act of performance, not in the reading of performance by an audience after it is captured, but as the performer, director, animator and operator generate performance for capture in the moment. A thorough examination of performance capture may hold the answer to this dilemma and contribute to fields of enquiry that exist beyond the motion capture studio in film, animation, dance and performance studies.

The primary question of the thesis asks:

> What constitutes the field of performance capture in the early 21st Century?

And then interrogates the following three sub questions:

> How effective are the standard processes for capturing performance, and is the current workflow ideal? How can it be improved? Can it be better?

[5] Auslander's *Liveness* (1999) is a vital text in the preliminary understanding of what is captured in the act of recording performance. I have gone to great lengths to avoid using this now canonical text in this study as it is widely understood and cited. I do however acknowledge Auslander here as an important voice in this field.

What domains of understanding contribute to a new approach to performance in both physical and virtual space?

What historical, practical and theoretical perspectives can serve to account for, and expand, our understanding of the field of performance capture?

Filling the space

In order to address these key questions a documented series of practical experiments were carried out in two optical motion capture studios: the Deakin Motion.Lab, at Deakin University, Melbourne, Australia and the Virtual Television Studio at LUME, in the School of Art, Design and Architecture, at Aalto University, Helsinki, Finland. The final artefact, this thesis in its entirety, is imbricated with ten edited, rich media packages drawn from three practical workshops undertaken in these studios between July 2010 and July 2012. The edited packages result in a documented body of work that demonstrates the process of the exploration undertaken in this study. The ten illustrations of practice (IoPs) should be viewed as an integral aspect of the thesis. These packages are intimately connected to specific subject areas and detail vital aspects of the practice undertaken with operators and performers in MoCap studio environments. It is suggested that an electronic copy of the thesis is read with an enabled connection to the web, as the files are hyperlinked to an online source. In the event that this is not possible (or the thesis is being read in analogue) the links are listed at the back of the thesis and a copy of each file is included with the attached flash drive. Hyperlinks to the ten files are also available here:

IoP#1, IoP#2, IoP#3, IoP#4, IoP#5, IoP#6, IoP#7, IoP#8, IoP#9, IoP#10

The order prescribed is a suggestion only. The IoPs can be viewed out of sequence, but are referred to, and are linked, in a specific order that follows the logic of the document. As an introduction to the practical aspects of MoCap and

the accompanying Illustrations, the first package should be viewed now via this link. This package reveals aspects of the study encountered as the thesis progresses, and demonstrates the PeCap process in a condensed mode.

Fig 3: Image extracted from IoP as Lois Weaver performs from Workshop #3 July 2012
(Image M Delbridge 2012)

Practice Based Research

Constructive and exploratory research principles were applied to address a gap in existing knowledge on the place, function and altered purpose of performance using MoCap in PeCap scenarios. Where performance in MoCap is focused on the practical capture of movement for a specific purpose, for example a walking cycle for animation in a video game or analysis of the knee in a human

movement study,[6] PeCap is the capture of an entire scene or performance using a motion capture system. This study questions the MoCap infrastructure when applied to PeCap, and the workshop cycles are central to the development of the PeCap methodology.

Each workshop involved the same operator and system with three different sets of performers. The workshop cycles were designed to challenge the existing workflow of the optical motion capture studio, transforming the mode of capture from MoCap to PeCap.

Workshop 1
Conducted at the Deakin Motion.Lab over a week in June 2010 and two weeks in July 2011 with two early career professional actors.

Workshop 2
Conducted as part of a motion capture masterclass at LUME, Aalto School of Art and Design in Helsinki, over a week in January 2012 with three actors in their final year of acting studies at the University of Tampere

Workshop 3
Conducted at the Deakin Motion.Lab in July 2012 with two professional actors with over 30 years experience as independent touring artists.

The studio is an environment I am able to "make sense of or to interpret in terms of the meanings people bring to it" (Denzin and Lincoln 2000, p3). Throughout, I locate myself in the motion capture studio and have remained conscious of developing a re-understanding of the term performance capture. It may seem, at first glance, that the participants observed in the workshop cycles are encouraged to exhibit notions of nativeness in performance; however, they are

[6] The walk cycle is a common animation term where a sequence of frames are drawn to represent the walking motion of a character. It can be a time consuming and costly process. Using a MoCap system to generate a walk cycle is cheap and fast.

not strictly natural inhabitants. The operator of the system, present throughout all three workshops, is the native, and is a significant object of the study. This notion of ‘nativeness’ is explored throughout the thesis.

Departing from the traditional qualitative framework (but acknowledging the qualitative as its root), the study deploys a practice-based approach to data gathering and self-reflection, where the researcher occupies an ambiguous space that works within systems of complexity and emergence. Research occupies a core position of practice-based enquiry (and in this case a praxical approach, allowing theory to lead the practical). Due to the nature of studio practice, the questions under interrogation allow for a shift as the work evolves. Estelle Barrett asserts that “the critical and inextricable meld of theory and practice” is central to any creative practice enquiry, and that praxis is at the heart of this process (2010, 6). There is an intimate relationship between theory and practice here, one that allows practice within the studio to be informed by theoretical discourse, and for a theoretical direction to be determined by emergent discoveries realised in the studio.

For Haseman and Mafe, the work of a creative practitioner undertaking research **“**represents something of a quantum shift in the creative researcher’s thinking, now the art-making and the artwork itself are no longer to be thought of as existing solely within their disciplinary field” (2009, 215). The work that has emerged from the MoCap studio responds to much more than just single fields of either performance, animation or film. It responds to all three areas as an interdisciplinary practice, with the contributing literature that has informed this practice arising from a variety of discourses relevant to the studio and the study.

MoCap is a tool for documentation and capturing movement while PeCap is the mode of performance that uses a motion capture system. The challenge within the study is concerned with the preparedness of creatives to effectively work within hyper-mediated performance spaces that deploy performance capture.

The study design has, therefore, emerged from a tacit response to professional experience working within motion capture studios. The dissemination of knowledge from this study challenges traditional research output strategies that report through the language of performance. In this case, the captured induction processes and edited enquiry sequences from within motion capture studios on modelled screen-based stages are found where:

> The performance researcher asserts the primacy of performance as a research output and join(s) their colleagues in the creative arts by acknowledging that for the choreographer it is dance, for the designer it is material forms, for the poet it is the sonnet, and for the 3-D interaction designer it is the computer code and the experience of playing the game which stands as the research outcome. (Haseman 2009, 57)

While significant components of the study are devoted to the exegetical, to replay the findings through words alone would dilute the significance of the outcomes. For this reason, the documented practice of preparing for performance capture scenarios forms an ongoing aspect of the reflection central to the work. There will be many conclusions drawn from the workshops and the discussions that play out as a result of this study, but the most fundamental are concerned with the plotting of a roadmap for the future of PeCap as a rigorously defined and understood interdisciplinary form. This can only be understood and applied through practice with performers, directors, animators and operators in MoCap studios.

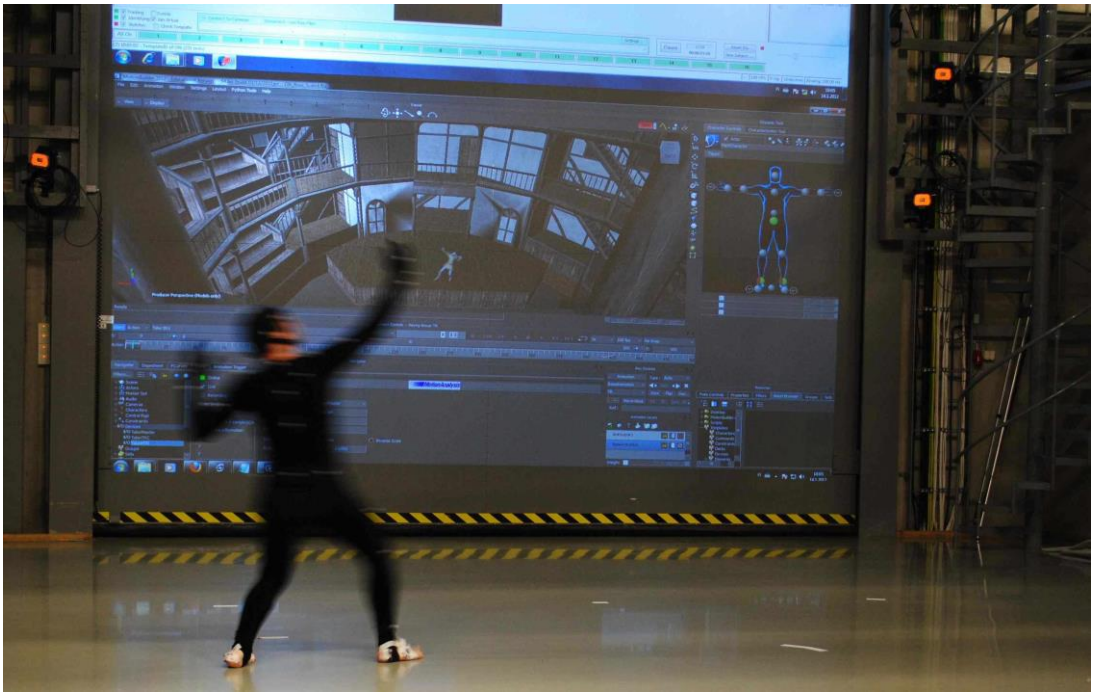

Fig 4: Live Stream into 3D model of the Rose Theatre from Workshop #2, Helsinki 2012 (Image M Delbridge 2012)

Systems

The system for all three cycles was a 24 camera Motion Analysis optical motion capture system with a workflow streamed into two software-based virtual environments. The first of these environments, Cortex, is the capture interface between external hardware (cameras and capture suit) and the performer that generates a performer's initial template. The second environment, MotionBuilder, an Autodesk software tool, takes the actor's template as an input and uses this template to drive avatars in a real time 3D space. The systems used in the workshops were very similar, deploying the same hardware and software in each test cycle. The significant difference between the Melbourne and Helsinki sites was the size of the capture volume, the amount of space the motion capture system could see. In Melbourne this volume was 7 x 7 metres, in Helsinki the volume was 10 x 10 metres. This change in volume size allowed for three actors in Helsinki to be captured at once, adding an extra layer to the workshop exercises. Control measures in the workshops included the unifying principles of the software workflow deployed in each cycle; the use of a large multi camera Motion Analysis motion capture system at both sites; the presence of the same

operator and my role in each workshop; the same screen-based performance venue and avatar – The Rose Theatre and shakespearean actor avatar (SAA).

The Rose Theatre and Shakespearean Avatar

The actors were prepared for a performance to be captured on a modelled Elizabethan stage. The modelled stage was generated from drawings of The Rose Theatre, an Elizabethan playhouse from London in the 1590s. The model was constructed by Ortelia, a company specialising in constructing interactive 3D environments for historical and cultural research, and was used as a test environment for the actors because of its particular performance limitations.[7] The venue was used for the challenges it posed, and these challenges are representative of any screen-based environment. The Rose is a shallow, yet very tall playhouse, comprising three balconies, a small stage area, a gallery above the stage and a tiring/backhouse directly behind the stage. Due to its particular size and scale it offered many challenges for a performer. The multiple viewing areas in the audience, for example, facilitated a pragmatic set of environmental performance conditions for the test cycles. The Rose Theatre, seen in Figure 5: The Circular Nature of The Rose Theatre (Delbridge 2011), is similar to our current understanding of the performative conditions of venues like the recreated Globe, but the Rose is much smaller and demands an alternative discipline of performance to connect to all areas of the venue. These challenges will be discussed in more detail as the thesis progresses and explored in the Illustrations of Practice (IoP). Central to all three workshops was the need for each performer to drive a purpose built shakespearean actor avatar (SAA) on the stage (see Figure 1 on page 12). In the driving and control of the SAA in the blank MotionBuilder workspace and the modelled Rose Theatre, the performers navigated a number of challenges concerned with the MoCap environment. How they responded to both venue and character inform the development of this new

[7] For more information see http://www.ortelia.com

approach to PeCap. These conclusions are applicable to all modes of performance that occur in the binary of physical and virtual space and are central to the eventual findings to be drawn from this research.

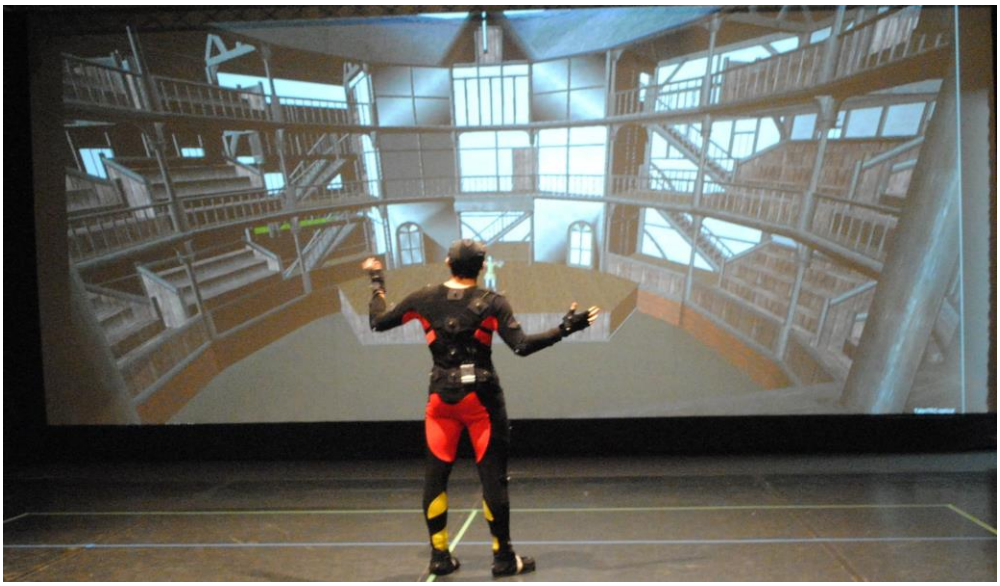

Fig 5: The Circular Nature of The Rose Theatre Deakin Motion.Lab (image M Delbridge 2011)

The Operator

All the devices mentioned in this study, either historical or deployed in the practical components of the project, are manipulated and controlled by operators capturing performance. In the contemporary mediation between device and performance, the operator is firmly located within the digital frame. This relationship is key to understanding how capture technology has developed over the last century, and provides an approach for this research to unpack the dilemma of performance captured and reproduced. By placing the operator at the centre of a discussion concerned with the development of digital content for the animated film, computer generated imagery (CGI), live performance and video game industries, this research proposes a major shift in the ongoing development of performance capture. This includes a re-learning of approaches for those within the conservatoire, and a broader reimagining throughout the profession.

Fig 6: Delbridge Operating MoCap system in 2006 (Image S Fox 2006)

Building the Picture

Over the course of this study, five domains of understanding have emerged from a theoretical and interdisciplinary cross section of theatre, film and animation discourse that underpin a revised deployment of performance capture. These domains are: Infrastructure and Workflow, Language, Spatial Framing and Feedback, Tool Use and Time, and Environmental Navigation. Presented in this order, they form the structure of the thesis.

These thematic areas are rooted to interrogating the central research questions. They also support the dissertation's exploration of the relationships between each domain. This demonstrates a practical approach to a deeper understanding of motion and performance capture. It does not suggest that every practitioner entering a motion capture studio needs an intimate knowledge of the work of

anthropologist Tim Ingold or the spatial theory of Henri Lefebvre to be successful as a MoCap artist. Rather, it recommends that those seeking a rigorous working relationship in capture spaces can apply a theoretical discourse that adds layers of meaning and understanding to their work. This understanding forms an element of what is referred to here as 'common knowledge' and is important when motion capture spaces are explored for the first time. It informs my work, and should continue to inform the work of operators, directors, animators and performers who occupy these environments in an ongoing capacity.

The study contributes to an established discussion of visual tools for performance: tools used to perceive, navigate, capture and display the live, the digital and mechanically mediated. These tools can be classified in broad terms as Victorian-era spectacle machines, film cameras, motion capture systems and screens (in all of their permutations). The machinic and the digital frames are traced through an examination of the impact of the birth of film on the place, function and primary performative focus of the operator and actor, and in defining what have since become the major points of difference in performing for the stage versus the filmic frame. The deployment of this historical and conceptual optic informs the background to issues around more recent modes of digitally capturing performance in which we find an altered focus from manual and machinic tools to systems that enable performance capture

I acknowledge that there are other thematic areas not included in the thesis that could also contribute to this emerging discourse. The scope of this dissertation has been limited to these five domains so that a foundation for future exploration can be established. As it is a growing area of scholarship and practice, I anticipate that this work will be viewed in the future as the foundational study of PeCap. As such it is only fitting that there be space for further contributions to be made, and I acknowledge that there is ample opportunity for further research to be undertaken in this area. The range of significant people discussed in this study, from spatial theorists to authors of motion capture 'how to' guides, are

deployed for a variety of reasons. Their selection demonstrates a genealogy of thought and practice rather than an in-depth study of each individual's work. It is important that this genealogy be acknowledged as it provides a link to a historical, practical and theoretical discourse suitable for the development of PeCap as a form.

The literature review woven throughout the work focuses on the place and function of mediated performance in recent history, including definitions of space, the ecologically perceived in an environment, and early film discourse. It identifies the scope of the historical and theoretical discourse undertaken, and is embedded and applied throughout the body of the exegesis. The sophisticated relationship between theory and practice has progressed to the extent that there is no way of distilling one from the other. Scholarly material addressing the place and function of motion capture in contemporary performance (including recorded media forms) is limited. This is reflected in an ongoing capacity throughout this dissertation, and is a primary motivation for the study to be undertaken. Figure 7 lists the key figures deployed in this study, presented in a historical timeline.

Fig 7: Timeline of Theoretical Discourse (Image M Delbridge 2013)

The structure of the thesis has been devised to provide a logical journey through this selected historical timeline of thought and practice. While in the diagram it is presented as a linear progression, in the study each practitioner and/or theorist is used as and when necessary (outside of the linear). This non-linear perspective highlights advances in technological devices related to MoCap, identifies aspects of relevant philosophical discourse and reveals modes of artistic and technical practice that inform the development of PeCap where most appropriate.

The dissertation is divided into seven sections: an introduction and study design, dedicated to scoping the study and laying the foundations for the identified domains of understanding through this plotted history; five chapters, dedicated to each of the domains of understanding; and a final section that presents the findings from the study and draws conclusions around what is possible now, what can happen as a result of this thesis and what needs to change into the future to accommodate these findings.

The first chapter, Infrastructure, provides an examination of the existing infrastructure of motion capture. It draws on three primary texts to begin a constructed historical perspective of MoCap and interrogates principles particular to the animation discipline. The primary texts that foreground this chapter are Midori Kitagawa and Brian Windsor's *MoCap for Artists* (2008) and Matt Liverman's *The Animator's Motion Capture Guide* (2004). To a lesser extent, Alberto Menache's *Understanding Motion Capture for Computer Animation* (2010), Ricardo Tobon's *The MoCap Book* (2010) and Derek Hayes and Chris Webster's *Acting and Performance for Animation* (2013) are also referred to, but these three are less significant to the field. These five texts are the only works available that focus on the principles and workflow of MoCap and are presented as 'how to' guides for animators. They are used in this chapter to demonstrate the ongoing privilege of the tool over the form, so often found in commercial studios, where the motion capture system, workflow and captured movement data is a primary focus and the direction of performance is of secondary concern.

The second chapter, Language*,* unpacks the emerging language of MoCap. It examines the complexity of the competing and complimentary forms of language that emerge when individuals arrive in the MoCap studio from disciplines with their own traditions. The chapter reveals the limitations of language in the MoCap studio, introduces the workshop participants from the practical aspects of the study and begins to generate a common language for PeCap, which emerges from an active translation of terms used in motion capture. Nine discrete terms that do not come from the disciplines of theatre, film or animation are introduced here. The ongoing identification of this language contributes to a growing understanding of the complexity of MoCap and the place that PeCap needs to occupy as an interdisciplinary form in the academy and in industry.

The third chapter, Space and The Frame*,* explores how spatial awareness contributes to devising practical PeCap exercises in the studio. This chapter establishes the relationship between theory and practice in this research. It draws from the theoretical discourse of Oskar Schlemmer (1925), Henri Lefebvre (1958), Gaston Bachelard (1991) and Jean Baudrillard (1981-93) to examine how aspects of their work can be applied to a spatial understanding central to MoCap. This chapter looks closely at the practical work completed in the workshop series and interrogates a group of exercises devised in response to the complexities of performing in both physical and virtual space, as well as providing a practical response to the theoretical discourse deployed in the study.

The fourth chapter, Tool Use and Time*,* interrogates a discourse from early film to examine the act of generating performance for a device and the ensuing and necessary interrogation of what is philosophically captured in the act of performance for MoCap. In this chapter, an early fiction work by Luigi Pirandello, *Shoot! (Si Gara!) The Notebooks of Serafino Gubbio* (1926), is used to examine the intimate relationship of the operator to the capture device. This intimacy, paralleled in the MoCap studio between system operator and performer, is a fundamental aspect of the PeCap scenario, and privileges the operator of the

MoCap system in the successful generation of performance. In addition to Pirandello, Walter Benjamin's *The Work of Art in the Age of Mechanical Reproduction (Das Kunstwerk im Zeitalter seiner technischen Reproduzierbarkeit)* (1936) is used to support Pirandello's influence of the operator, framing the dilemma of what is actually captured in the act of recording performance as the capture and reproduction of aura.

The fifth chapter, Environmental Navigation, interrogates the development of practical navigation and exploratory exercises devised in the workshop series. These are identified as vital contributions to the performer's visual and physical exploration of virtual space. It articulates a contemporary understanding and application of ecological navigation, drawing on the work of James Gibson (1979), Tim Ingold (2009) and Jacob Von Uexkull (1934) to examine the complex initiation undertaken when the MoCap studio is encountered for the first time in PeCap. It interrogates how the discrete perspectives in an interdisciplinary environment need to work in unison and uses an ecological perspective to make sense of the unique physical properties that exist in the MoCap studio.

Fig 8: MoCap Live Stream Deakin Motion.Lab workshop 2010/11 (Image M Delbridge 2010)

Research Significance

In 2011, Theatrical Market Statistics, an annual report released by the Motion Picture Association of America, declared the revenue for all cinema releases across the world (Global Box Office) at US$32.6 billion. A year later, a report from Reuters estimated the worth of the global video game industry, including online, smart phone and console games, to be US$65 billion (a 10 per cent increase from the previous year). One useful illustrative example occurred in November 2011. Within 24 hours of going on sale, *Call of Duty – Modern Warfare 3 (MW3)* grossed US$400 million. The console game sold 6.5 million copies in the US and UK, making it the biggest entertainment launch of all time. It went on to gross US$1 billion throughout the world in 16 days, beating the feature film *Avatar* (2009), which grossed the same figure in 17 days. The one similarity associated with these incredibly successful, record-breaking products is their reliance on motion capture, specifically the work of animators, directors, operators and performers using a capture technique known as performance capture. A new mode of generating content for film and video games has been established. A revised approach to the direction of performance is urgently required.

Performance in motion capture environments is a unique discipline – and the concept of capture is particularly important when we come to describe this significance. Those who are successful in this type of work are rarely appropriately recognised for the significance of their contribution. A large proportion of the success of the products they are involved in should be attributed to the work of the operators, performers, animators and directors who generate the material. At its simplest, this is demonstrated within the credits of video games, where the actors that supply the movement of ingame characters (minor though they may seem) are not acknowledged. A recent phenomenon has seen motion captured features deemed ineligible for best animation feature nominations and actors snubbed in best actor categories in the Academy awards because they were motion captured and not filmed (see Soares 2013, Gilsdorf

2012 and Dallas 2011).[8] Andy Serkis brought Gollum to life (and the Witch King of Angmar) in *The Lord of the Rings* trilogy (2001-3) and *The Hobbit* (2012), King Kong in *King Kong* (2005), Caesar in the recent blockbuster *Rise of the Planet of the Apes* (2011) and Captain Haddock in the *Tin Tin* (2011) series of films. In addition he was also second unit director on *The Hobbit* (2012) and a video game director, with cut scene sequences in *Enslaved: Odyssey to the West* (2010) and *Heavenly Sword* (2007) directly credited to his production company. Serkis' performance as Caesar in *Rise of the Planet of the Apes* was critically acclaimed as one of the most notable performances on screen in 2011. Yet no performance capture Actor has ever been nominated for an Academy Award – *Avatar* (2009) was nominated for 9 Academy Awards, but none of them were for acting. Performance capture is regarded as a medium for a strange hybrid of animator and director, but it is fundamentally a medium for acting and performance. The majority of voters in the Academy are actors, and they are yet to understand performance capture as a legitimate form of performance for the screen.

A final cautionary tale worthy of mention is the tension between recent accolades and awards received by Ang Li's *Life of Pi* (2012), and the unfortunate demise of the company that produced the special effects central to the film's success. Lauded worldwide as the true award winners for the film, Rhythm and Hues, a Los Angeles based company founded in 1987, were forced to lay off 250 personnel only weeks before the Academy Awards. They have since been taken over by Indian visual effects (VFX) company Prana Studios, a sign of a much larger trend in the industry, where a significant amount of VFX work is being undertaken in India, China and Malaysia where costs are significantly cheaper. Anecdotal evidence suggests that there are more MoCap systems currently being installed in mainland China than anywhere else in the world. This shift in geographical and cultural focus will have an impact on methodologies for best

[8] This theme has been repeatedly discussed in the media over the last few years. See Gilsdorf in Wired.com Feb 2012, Dallas in IF online magazine October 2011 and Soares in Alt Film Guide February 2013. The full links to these articles are available in the bibliography.

practice for performance and system operation in the future of commercial PeCap and MoCap.

Central to the growing significance of motion capture as a major tool in the ongoing development of screen content into the future is how consumers will continue to interact with the content that is produced. In the future, the framed screen will become much less important against the rising significance of a totally new visual experience that will take the form of a projected performative volume in space. The concept of volume is discussed in detail later in the thesis, but for now it might look like the holodeck in *Star Trek*: *The Next Generation* (1987), or Princess Leia asking Obi Wan Kenobe for help in the original *Star Wars* (1977). Steven Spielberg, quoted in a recent opinion piece (June 22nd in *The New York Times*) concurs with the end of screen-based entertainment:

> We're never going to be totally immersive as long as we're looking at a square, whether it's a movie screen or whether it's a computer screen…We've got to get rid of that and put the player inside the experience, where no matter where you look you're surrounded by a three-dimensional experience. That's the future.
> (Spielberg in Rose, 2013)

The rich media experience of the future will probably be something closer to our current understanding of a theatre in the round, and our home entertainment systems will occupy not just space on a wall, but an entire room. The only way this sort of content can be captured for presentation using current technology is performance capture, and we are not planning for this potential future in either the institution or the academy. The theory, practice and findings brought together in discrete but inter-related chapters in this study provide some preparatory steps to prepare for this future. The overwhelming popularity of recent initiatives like the National Theatre Live (NT Live) is an additional source of significance to this discussion.[9] The streaming of 'live' performance to our cinemas from the National

[9] For more information on this transformational approach to viewing theatre see the NT Live website, http://ntlive.nationaltheatre.org.uk/

Theatre in London, despite the obvious time difference, is anything but live, at best it is recent. As it arrives to us with all of the revitalised business models that accompany it in tow, this completely mediated experience is not live in the truest sense. As Auslander reminds us in *Liveness* (1999), before there was the technological ability to record performance we never referred to performance as 'live', it was simply performance. Performance capture has the potential to remove the mediation before content arrives to the consumer and to reshape our understanding of how audiences into the future will engage with live performance. The NT Live project also challenges our traditional understanding of the conventional role associated with the operation of devices in live performance. As the models of performance presentation shift, so too does the expectation and influence of the operator in the audience experience, particularly when the operator of a capture device mediates the audience experience.

Fig 9: Image from camera rehearsal NT Live – experience mediated by camera operator (image NT Live 2013)

A key aspect of the foundation for rethinking PeCap centres on the examination of infrastructural and methodological approaches deployed in the current capture of performance using optical motion capture systems. As well as considering these systems and their origins, the next chapter, Infrastructure, highlights the historical timeline of the medium and offers a brief interrogation of the tensions between animation and performance. It examines the inherited infrastructure of the Deakin Motion.Lab (as an example of a standard optical MoCap studio and site of two of the practical workshops undertaken in the study) and interrogates two prominent MoCap texts: Liverman's *The Animators Motion Capture Guide* (2004) and Kitagawa and Windsor's *Motion Capture for Artists* (2008), which dissect the tension between animation and performance.

Chapter 1
Infrastructure

Infrastructure

In order to fully explore the infrastructure of the MoCap environment we have to understand what is physically in the space, including how it came to be there and who is using it. This examination of MoCap infrastructure involves the historical development of devices that have led to current motion capture systems and the ways that these systems are set up, operated, maintained and used. The physical infrastructure(s) of this study conform to the studio environments detailed in the only texts available to explore the practical principles of motion capture. These are Kitagawa and Windsor's *MoCap for Artists* (2008), Alberto Menache's *Understanding Motion Capture for Computer Animation* (2010), Ricardo Tobon's *The MoCap Book* (2010) and Liverman's *Motion Capture Guide* (2004). I have drawn predominantly from Kitagawa and Windsor (2008) and Liverman (2004) as these are the most widely used and regarded MoCap texts. To varying degrees of success, each 'how to' guide actively provides insight into the historical development of MoCap as a medium and can serve as a primary reference point for the various motion capture infrastructures available (including how they are best used). There is a fifth text available that connects MoCap to animation, Hayes and Webster's *Acting and Performance for Animation* (2013), but this is more focused on framing the function of animation as 'acting' than on teaching MoCap, though it does refer to motion capture at various times. As this study asks how effective the processes for capturing performance are, and whether they can be improved, there are several assertions made in these texts that are actively challenged. The methodological principles prescribed in these 'how to' texts overtly privilege the experience of the animator in the process of motion capture and discreetly (yet significantly) minimise the experience of the performer, director and operator. This underlines the innovation this research adds to the standard infrastructural requirements of a contemporary motion capture workflow.

Within this context the infrastructure of a motion capture studio is defined as the equipment and organisational structures required that facilitate the capture of

performance. This includes the human, data, equipment, and capture management systems that ensure the system components are being fully utilised and movement is being captured. An examination of the significant components of the prescribed organisational structure required for motion capture projects (informed by the three workshops undertaken in the studio) has revealed opportunities to enable the shooting of performance capture. This chapter is divided into three parts in order to interrogate the current infrastructure of MoCap. The first part presents a brief historic survey of the pioneers of early motion capture: Eadward Muybridge, Etienne Marey, Harold Edgerton and Max Fleischer. The second examines the common methods employed in motion capture studios (drawn from the two primary texts) that demonstrate current practice in learning motion capture. This approach includes the need for animators to frame the capture of performance around the *12 Basic Principles of Animation* (Johnson and Thomas 1981) and the inherent problems associated with this.[10] The third section discusses the infrastructure of the two sites of capture used in this study, the Deakin Motion.Lab and the Virtual Studio at LUME, in Helsinki, and details seven common infrastructural capabilities necessary to undertake optical motion capture: a camera array, workstations, a capture space, motion capture suit and marker set, software workflow, personnel and a pre-visualisation set up. The purpose of this infrastructural discussion is to outline the basic principles at the core of motion capture and contribute to a growing understanding of the current approach employed in many MoCap studios today. The conclusions drawn from this establishes infrastructure as a key domain of understanding for this growing discipline, and begins to define the field of PeCap for the twenty-first century.

[10] See Disney animators Ollie Johnston and Frank Thomas text *The Illusion of Life: Disney Animation* (1981). Johnson and Thomas were two of Disney's 'Nine Old Men' responsible for animated features including Mary Poppins (1964), Sleeping Beauty (1959), Winnie the Pooh (1977), Fantasia (1940).

Early Motion Capture and Rotoscoping

The earliest forms of motion capture existed before the digital age and can be attributed to three photographic pioneers: Eadward Muybridge, Etienne-Jules Marey and Harold Edgerton (Kitagawa and Windsor 2008). The Muybridge contribution is regarded as the precursor to contemporary filmmaking and animation, and was achieved by a dozen cameras in an array taking sequential photos triggered by the movement of a horse's feet. This famous image was generated by a series of frames captured in sequence by the camera array as a commission to settle a bet for Leland Stanford over whether a horse in a canter had all four feet off the ground at any one time. It is the first surviving record of captured movement, or, more precisely, the capture of movement over a determined period of time. Muybridge later invented the zoopraxiscope (1879), a device "which projects sequential images on disks in rapid succession", considered to be one of the earliest motion picture devices (Kitagawa and Windsor 2008, 2). Muybridge's texts *Animals in motion* (1899) and *The Human Figures in motion* (1901) are still used by students of anatomy, animation and filmmaking today.

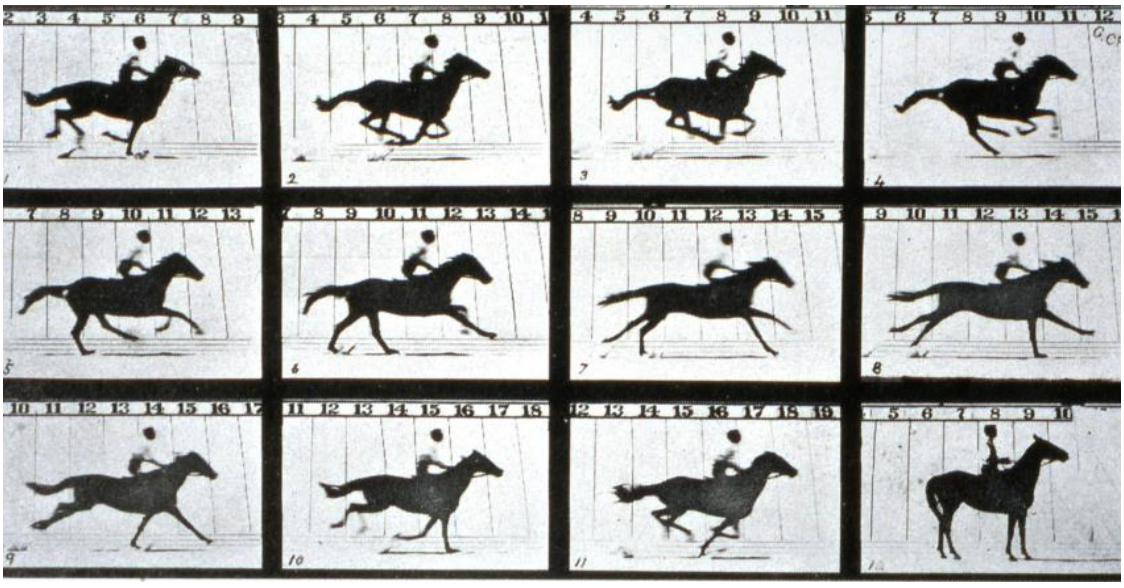

Fig 10: Horse in motion (Image E Muybridge 1872)

In 1882 Etienne Jules Marey met Muybridge in Paris and was inspired to invent the “chronophotographic fixed plate camera with a timed shutter that allowed him to expose multiple images (sequential images of movement) on a plate” (Kitagawa and Windsor 2008, 2). This device was similar to Muybridge’s zoopraxiscope, but when Marey used his recording device in conjunction with a special suit designed to allow a plotted record of human movement to be extracted from the image sequence, he set the scene for our contemporary version of motion capture.

Fig 11: Marey’s motion capture suit (Image E Marey 1884)

The last of the three pioneers, Harold Edgerton perfected his own version of the lighting instrument known as the stroboscope (or strobe) in the1930s. While the strobe light had been in development since the1830s, Edgerton’s innovation was his ability to use electronics to match his flashing light to the revolution of a rotary

motor so that it appeared stationary. That Edgerton further developed his strobe to be used as a flashing light to photograph fast moving objects on film was in fact a by product of the initial purpose of the electronic stroboscope in the maintenance and testing of rotating machine parts. When used in conjunction with photography, however, his advances in stroboscope technology did provide a primary step in the development of current optical motion capture.

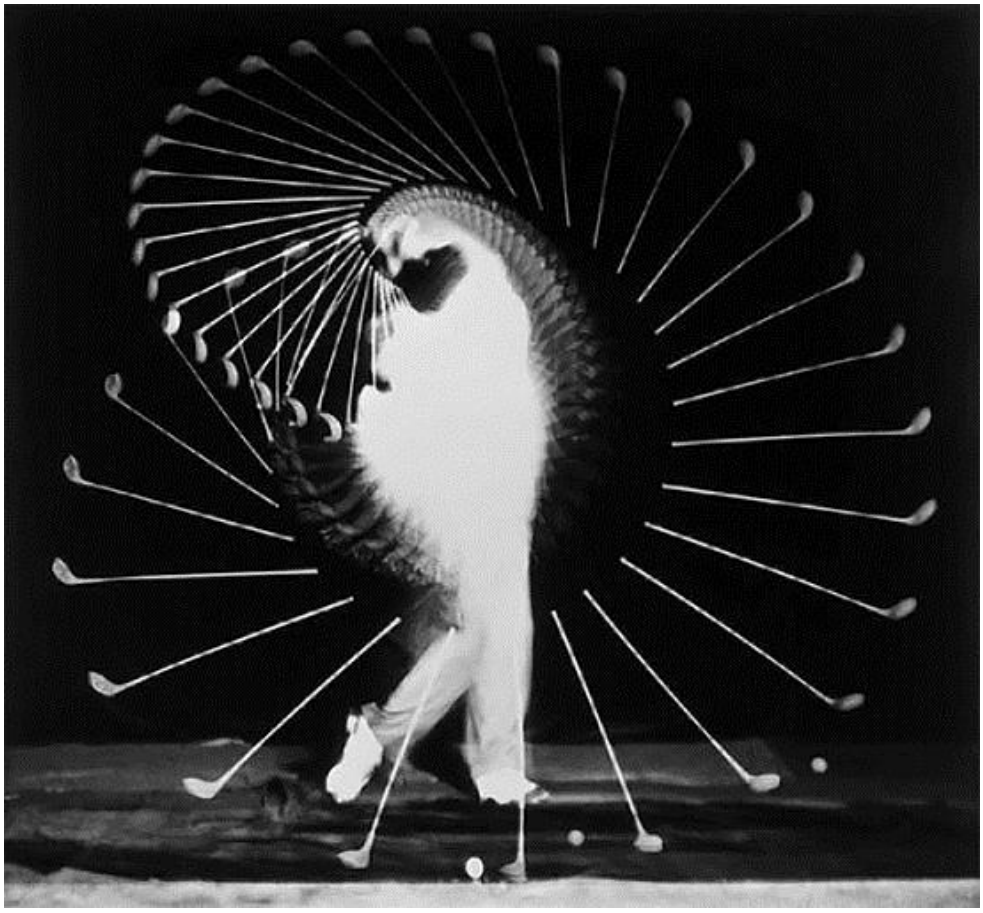

Fig 12: Golfer Densmore Shute recorded @ 100 flashes/second (image H Edgerton 1938)

Max Fleischer, Rotoscoping and Disney

Rotoscoping was first developed by Max Fleischer, the creator of the cartoons *Betty Boop* (1930) and *Popeye* (1933). It was later exploited in feature films by Disney studios, with the first animated feature to use rotoscoping *Snow White and the Seven Dwarves* (1937). At its inception rotoscoping was the process of tracing around individual frames of traditional film to be repurposed and colored

as animation. Fleischer developed several experimental films using his rotoscoping technique with himself in real life “interacting with animation characters” (Kitagawa and Windsor 2008, 6), but it was Disney that pioneered the use of rotoscoping to become a study of human and animal movement. It is little known that “Snow White and Bambi contain live action film footage, rotoscoped to look like completely hand drawn animations” (ibid).

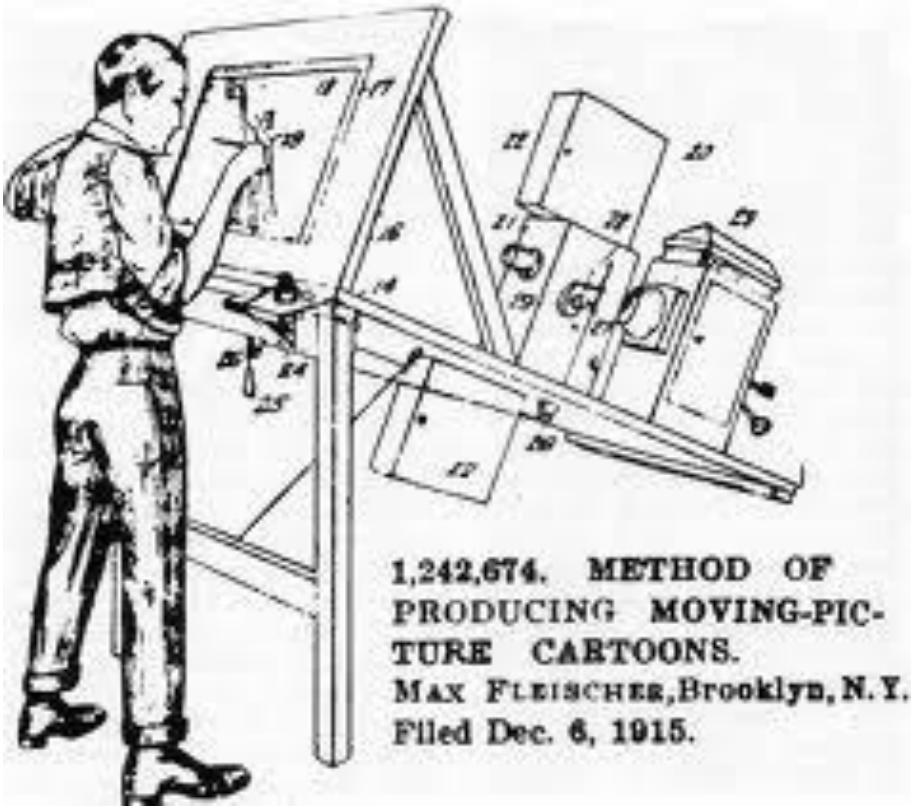

Fig 13: Fleischer detail of rotoscope method from patent submission (image M Fleischer 1915)

While medical and military research into digital motion capture began as early as the 1970s there was no impact on the industry of computer generated imagery (CGI) until the mid 1980s, and even then the technology met with little impact. The first commercial application of what can be described as 3D animation was for a commercial of a cleaning product aired as part of the Superbowl in 1985. The commercial called *Brilliance* (1985) depicted a female robot that moved like a real person. The producers of the commercial developed their own form of

motion capture to give the robot lifelike qualities: “They painted black dots on 18 joints of a female model and photographed her action on a swivel stool from multiple angles” (Kitagawa and Windsor 2008, 7). *Brilliance* (1985) was acclaimed for its startling attention to the lifelike attributes of the animated robot and heralded the beginning of the optical motion capture industry we know today.

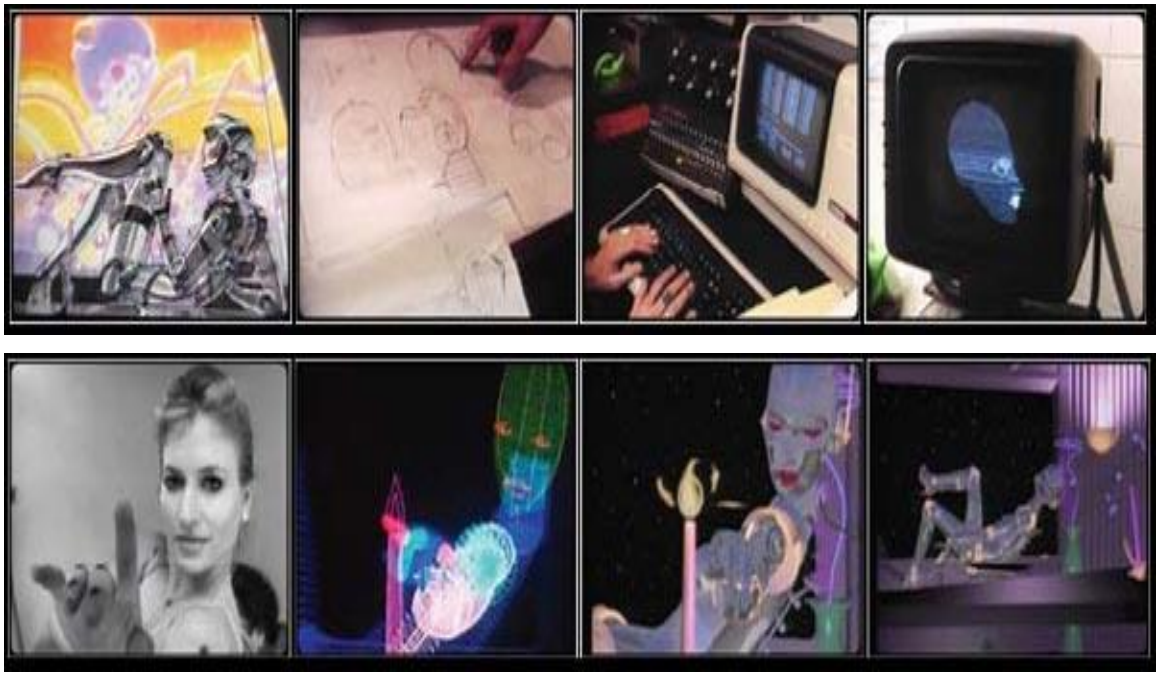

Fig 14: Images taken from the making of the *Brilliance* commercial, Superbowl 1985, the first commercial use of MoCap (Image Ketcham advertising 1984)

MoCap Workflow, Performance and the Twelve Basic Stages of Animation

A formally trained animator will be used to devising motion and movement from scratch, and, depending on their training, will work to what are known as the 12 Principles of Animation. Devised by Disney animators Ollie Johnston and Frank Thomas, the principles are most often reproduced in the training and education of animators in MoCap from various sources, in this case Liverman’s *Animator’s motion capture Guide* (2004). They were originally published in *The Illusion of Life: Disney Animation* (Johnson and Thomas 1981). The twelve principles are: Anticipation, Arcs of Motion, Ease In and Ease Out, Exaggeration, Follow Through and Overlapping Action, Secondary Action, Squash and Stretch,

Staging, Timing, Solid Drawing (or Weight and Balance) and Personality (or Appeal)

Anticipation is movement in the opposite direction before the main action starts. Arcs of Motion are where objects travel in an arc through space as opposed to a straight line. Ease In and Ease Out depicts where most objects start slow, accelerate to a constant and then slow down before stopping. Exaggeration dramatises a character's emotions. Follow Through and Overlapping Action is the opposite of Anticipation, or what happens when movement comes to a stop. Squash and Stretch is the creation of weight, as in when a ball bounces it transforms into an oval shape when it hits the ground. Staging is the presentation of action and an idea in a clear fashion. Timing is the pace in which actions occur, specifically in relation to primary and secondary movements. Weight and Balance accounts for the distribution of a character's weight such that it shifts correctly as the character moves. Personality is the intangible quality of the character – voice, appearance and actions (Liverman 2004, 2-14).

Liverman suggests the animator working with motion capture will deploy these principles at varying stages of the animation process and breaks the use of these principles into three phases of an animators motion capture workflow: Preparation; Capture Session; and Post-Capture (2004,15). In the preparation phase (before entering the studio) he suggests Ease In/Out, Exaggeration, Follow Through, Staging, Timing and Personality are to be used by the animator in planning the characters, and the amount of movement required for the project. Most of what Liverman suggests for the preparation phase is accurate. The Exaggeration and Personality of the character will be driven by the data captured. The Ease In/Out, Follow Through and Timing of movement required from the performer – particularly if the data captured is used for video game character movement (poses and actions), which need be returned to and repeated as game progression is controlled by the end user (or player). These are vital points to consider when directing performers in the studio and a particular art to be

mastered in terms of directing action within this environment. However, when Liverman describes considerations for staging a scene in terms of the final frame of the camera position he neglects the most prominent advantage of using MoCap, that it will record the action of the performer globally within an omniscient frame in a volume of capture space. (see Chapter 3: Space and the frame for a more detailed discussion of this term)

While Liverman rightly plans for the frame to be selected as part of an orthodox storyboard process, it is not a vital step in the motion capture shooting plan. Liverman also neglects to discuss that there needs to be prescribed sizes in capture volume for shifting from either a football game to an intimate scene. Animators are used to working in a 3D screen space with almost limitless parameters, but this is not the case in a motion capture studio where the size of the capture volume (the amount of space that the system can 'see') is duplicated in screen space. In light of traditional approaches, which fail to attend adequately to Staging, this research argues that the planning of the performance to be captured must account for spatial consideration (see Chapter 3: Space and the frame for a more detailed discussion).

Liverman refers to the capture director as a "motion Coordinator", and the actor as a "motion Performer" (2004,16). His work suggests the roles "work together to *contribute* to the overall look of the motions captured" (ibid, MD emphasis). While acknowledging several of the principles will occur naturally during the process, he notes the principles of Anticipation, Ease In/Out, Follow Through and Overlapping Action and Timing can be coached, if only slightly (ibid, 17). This concept, 'slight coaching', is at odds with the approach to performance undertaken in the practical workshops central to this study. As opposed to coordinating motion, this project has demonstrated that performance needs to be directed. The performer does not simply supply the movement of 'everyman', they supply movement that comes from the core of who they are; they supply themselves. This concept, regarded as the performers 'aura' (and the

reproducibility of this) is central to this thesis.[11] This research, therefore, argues that the standard approach to performance and direction in MoCap studios is misunderstood from an animation perspective. For example, neither Liverman, or Kitagawa and Windsor note the immediate hurdle a performer encounters just by wearing a MoCap suit. Performing wearing a lycra suit covered in reflective markers has an impact on how an actor will perform. The texts do not acknowledge that depending on the material to be captured, the suit and markers may even become damaged or lost and that this can also affect the capture. This is a vital stage of the performer's and director's introduction and ongoing use of an optical motion capture system and doesn't even rate a mention in the 'how to' guides. The limitations of these texts underline a primary motivation for this study, to challenge the animation perspective which suggests that for the most part motion capture data can be fixed and transformed in Liverman's post-capture phase, where all 12 animation principles are reapplied to data generated in the studio. For Liverman, it is at this stage "the motion capture animator gets to use the principles and skills that most animators would consider truly animating" (2004,17). He acknowledges this stage is predominantly about "enhancing performance" (ibid) and through acknowledging the primary importance of the performance captured misses the stage in this workflow that enables the performer and director to properly drive the animation of the project.

In the workshop series conducted as part of this study, the 12 principles of animation were deliberately not discussed with the participants. Rather, the participants were allowed to navigate and explore the 3D workspace, first as a marker set cloud[12] and then to drive a neutral avatar in a pre-visualisation 3D environment, and, finally, to perform on an Elizabethan stage while driving a Shakespearean actor avatar (see Chapter 3: Space and the frame for a more detailed discussion). Their performances were captured continually in all three

[11] I draw the concept of 'aura' from Benjamin (1936) and discuss it in significant detail later in the thesis.

[12] This is the visual representation on the screen of the unlabelled marker set attached to the performer at the early stages of the capture process.

phases and streamed in real time from each software environment to a life-size screen, providing a source of continual feedback for them to respond to. The presentation of this feedback source shifted depending on the site of capture, and was enabled in different ways during the course of the study, based on the presentation equipment available. For example, at the Motion.Lab we predominatly used a large projection screen at one end of the studio (opposite end to the operator), and at Aalto we used multiple screens placed around the perimeter of the volume.

Infrastructural Inheritance

The physical and historical differences between the two sites of capture used in this project establish how infrastructure is read. The Motion.Lab is located on the backstage area of a theatre at Deakin University. It maintains a complete fly tower with 30 working lines, separate dressing room areas, a fully functioning theatrical lighting grid, loading dock, sprung floor and working sound system. The proscenium has been built in, but the fire curtain, complete with drencher, still remains. When you enter the Motion.Lab you instantly feel it's inherent theatricality[13]. The Motion.Lab is blacked out, has old cloths hanging in the tower and hemp ropes coiled over the loading galleries; it is a transformed space. It still feels like a theatre; its theatrical meaning is preserved. The significance of this for the actor and director is instantly clear. Most actors and directors will at various stages have formed relationships with theatrical spaces; however, this history is rendered meaningless if others entering the space (an operator or an animator) have no comparable theatrical experience. This research contends that the physical environment of the Motion.Lab enables performance, particularly as the experience of the director and actor is fundamental to the quality of the work captured there.

[13] In this study, theatricality is "a sign empty of all meaning, but the meaning of all signs" (Postlewait and Davis 2003 p1).

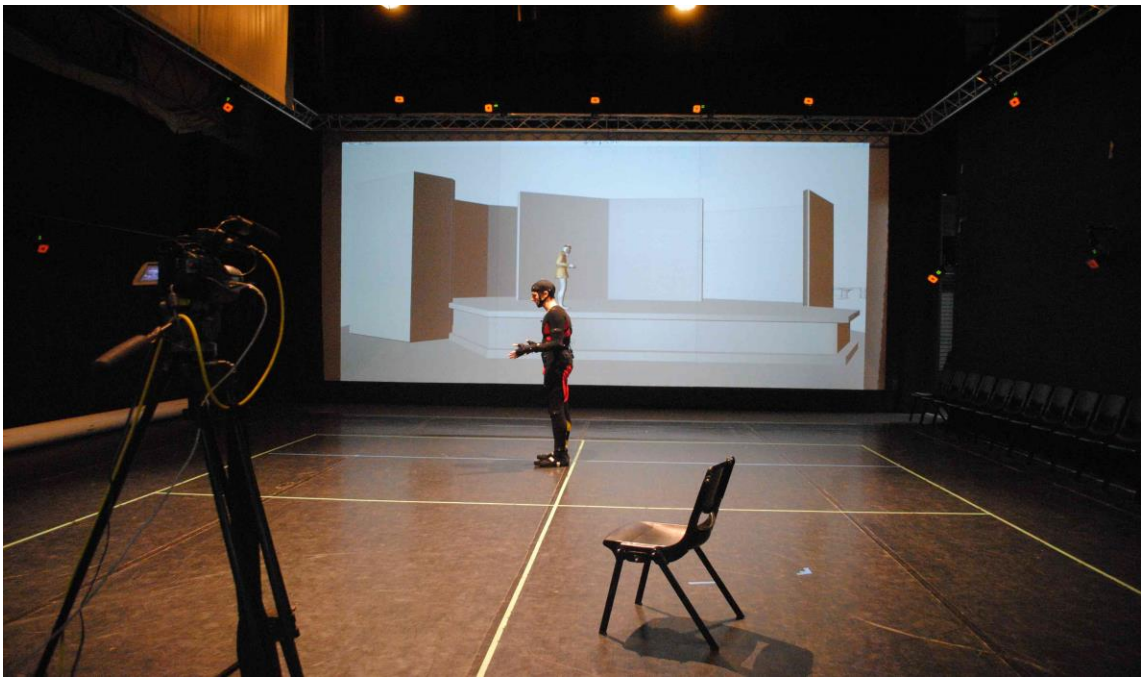

Fig 15: Deakin Motion.Lab + Virtual Screen Stage (Image M Delbridge 2011)

The Film and Television studio at LUME, Aalto School of Arts, Design and Architecture was established on the site of a commercial ceramics factory, Arabia, on the outskirts of Helsinki. The entire school complex was completed in 2005 and resides within the walls of the refurbished factory. This inspires a different working relationship with space. All of the studios (the film/tv studio is one of three studios located side by side on the ground floor) have ceiling heights in excess of 10 metres and footprints equal to the scale of a basketball court (see Figure 16: Film studio to MoCap stage Finland). Its primary use is as a teaching space for commercial television production, including virtual studio production – a technique that combines the use of green screen with motion capture, including real objects and people with computer generated imagery[14]. While the studio at Aalto had the physical infrastructure needed to undertake the workshop, the environment was drastically altered to enable the studio to capture the performance of actors with complicated marker sets.

[14] Unlike CGI filmmaking techniques that use similar technology but edit in postproduction, a virtual studio streams footage in real time primarily through camera movements that are tracked via motion capture in physical and virtual space. In virtual studio it is the camera that is tracked via attached markers and not the performer.

A motion capture set up to capture the performance of actors is significantly different to that required to track cameras, including the need for an altered software workflow to be implemented. The technicians looking after the studio, while accustomed to the principles of motion capture through their experience with virtual studio, were environmentally dis-located once the invigorated set up and workflow were implemented. The reconfiguration of the studio was a necessary step in preparing it for the capture of performance and a significant change to the activity that normally took place there. The experience of the technicians charged with the ongoing operation of the studio at Aalto is centred on the tracking of position and focus of traditional broadcast television cameras in a virtual studio environment. After I had adapted the system within to suit my own understanding of the potential of the space (through my own understanding of relative similar spaces), their respective understanding of their MoCap infrastructure was altered significantly and permanently. Worth mentioning is that after we had departed Finland, the technicians were able to return their system to its original state, for camera tracking, with ease, and now had the additional benefit of a physical set-up and software workflow that they could re-apply in the future to capture performance.

Fig 16: Film studio to MoCap stage Finland (Image M Delbridge 2012)

Key organisational and physical attributes of a Motion Capture Studio

While this study reconceptualises significant components of the prescribed organisational structure for motion capture it also acknowledges that there are physical and organisational attributes found in most capture facilities that need not change. There are seven attributes I have selected here that are framed as essential components of an Optical motion capture environment. The presence of these attributes needs to be actively acknowledged in the interrogation of the MoCap environment and the way it is established, operated and maintained. These attributes are: the camera array, control workstations, motion capture space, motion capture suit and marker set(s), software workflow, essential personnel and pre-visualisation set up. I need to discuss each of these attributes in some detail before examining the process the 'how to' guides use to determine the use of these aspects of a MoCap infrastructure.

The camera array includes all appropriate rigging and cabling for the array of cameras mounted on either portable stands or attached to a fixed grid. This array is connected to a data switch, which feeds the information to a control station. The motion capture technician primarily maintains the camera array. The cameras can be refocused depending on the shoot undertaken, accounting for the size of the capture volume required and the sort of motion to be captured.

There can be a single workstation or several workstations in a MoCap studio. This will depend on the complexity of the workflow. One workstation is required to receive/clean the data from the array, a second workstation to run previsualisation software and a third to manage administrative requirements of the shoot and store captured data. It is possible to run the system, previsualisation and data storage on one workstation. This management and use of workflow is determined by the studio technician and, when required, based on production, the director of the shoot.

Capture spaces can be any size, depending on the sort of capture to be undertaken including the size of capture volume required; an eight camera system will require a smaller space, and subsequently generate a smaller capture volume, while a larger system will occupy a larger physical space and volume. Standard practice dictates the capture equipment within the space will normally be the responsibility of the studio technician, but the management of the actual space may shift depending on the particular project and the qualifications required.

Studios approach suits and markers in different ways. A commercial film production will purchase a suit and marker set for each performer permanently attaching markers to each suit for the duration of the production – these suits and markers are normally disposed of after the shoot. A commercial studio offering motion capture services, on the other hand, will keep a stock of suits and markers to be used on an adhoc basis, depending on the requirements of the short-term hirer. These suits and markers will be subject to a maintenance schedule and reused repeatedly. The Motion.Lab is a space for hire, with a stock of around 15 suits in a range of sizes and multiple sets of maintained markers to be used. Traditionally, the scale of the production determined the organisational structure for suit and marker management in the capture studio. In a commercial film production this falls to wardrobe. In a casual hire and research environment it becomes the responsibility of the technical staff in the studio.

Several software packages are used in typical studio infrastructure. Depending on the optical system[15], there will be a specific capture software package (Vicon Blade or motion Analysis Cortex); the Motion.Lab uses a motion Analysis system; there is a previsualisation interface (MotionBuilder or Unity) and 3D animation software packages (Maya, 3ds Max, Soft Image) and other administrative

[15] In this study I refer to the two main suppliers of Optical motion capture Systems motion Analysis and Vicon. In both sites of the practical workshops a 24 camera motion Analysis System was used but in early tests of the study a 12-camera *Vicon* system was used as well. This study does not suggest which system is 'preferred' and the conclusions drawn from this study are applicable to use with either mainstream optical system.

software tools (Microsoft Office, etc). The management of the capture software is the responsibility of the studio technician. The use of pre-visualisation and animation software is operated by the technician (or the animator), but the capture director often determines its use.

Depending on the production, there are several personnel involved in a MoCap shoot. The minimum requirements are a technician/operator to maintain and run the system (depending on the workflow this could be two technicians), a motion capture director to direct the shoot (this person could be the animator that has designed the characters or a member of the production team in charge of the motion capture data) and the performer(s). The management of the personnel in the space shifts depending on the nature of the production, but it will typically be the responsibility of the motion capture director to ensure the shoot is complete. Additionally a motion capture supervisor may be present to manage the overall workflow of the system.

A pre-visualisation display will be available for the captured data to be viewed during production. In some instances this is simply a monitor, in others a cinema-sized projection screen. While there is always a display available in capture studios, this element of the system often goes unprivileged in the workflow. The management of the display will be the responsibility of the technical staff in the studio, with the displayed content determined by the motion capture director.

All four motion capture texts, *The Animators motion capture Guide* (Liverman 2004), *MoCap for Artists* (Kitagawa and Windsor 2008), *Understanding Motion Capture for Computer Animation* (Menache 2010) and *The MoCap Book* (Toban 2010) describe in detail the infrastructural requirements for successful motion capture in a variety of contexts. They privilege technological processes, data management systems, animation pipeline options, pre- and post-production planning and scheduling, and yet minimal reference is made in either to the directorial or performative requirements that enable the effective capture of

performance. All guides, which are useful sources for the technical operation of a MoCap system, neglect the central aspect of the capture and direction of live performance. The fifth and most recent text available, Hayes and Webster's *Acting and Performance for Animation* (2013), frames the process of animation as a performative act, comparing the generation of movement on the page to the process of the trained actor. At first glance, Hayes and Webster promises to bridge a needed gap in practical knowledge between the two disciplines, but this is unfortunately not the case. At best it provides a primitive connection between the acting process and animation, at worst it reduces the act of performance to that of function. Those who understand what it means to direct and perform, entering the existing infrastructure of a standard motion capture studio armed with Kitagawa, Liverman, Menache, Tobon or Hayes and Webster as a guide, will struggle to really understand the primary role they occupy in any workflow. The texts do not question the workflow processes of motion capture. They do not ask what it means to generate performance for a capture device, or the best way to introduce performers and directors to the complex infrastructure of a motion capture studio. They choose to focus on processes to be completed after the data is captured – that is post performance. Beyond reminders to rehearse and to be as prepared as possible, there is little to no emphasis on modes of promoting best-practice performance in what will be an alien environment for most actors. They tend to place performance on the periphery. The work of this research privileges the actor and the operator. In the motion capture infrastructure deployed here, which includes the organisational structures (human, data, equipment and capture management systems), the performance (and experience) of the actor and those directing and operating the captures are placed at the centre of the process. The resulting infrastructural innovations emerge from the practice of enabling performance in motion capture scene work. This practice has developed over the last eight years in Australia and the UK in a commercial capacity, in external research and consultancy commissions and, significantly, as part of this research project.

Conclusion

The physical and processual infrastructure devised through the course of this project is praxical in nature, evolving theoretically and practically on the studio floor. It challenges existing workflow frameworks found in motion capture studios and reveals an evolved approach that allows performance capture to occur. Infrastructure and workflow, as they are traditionally applied in commercial MoCap studios, privilege the generation of movement in accordance with the principles of animation over the principles of performance. The predominant texts used in the training of animators and technicians demonstrate the emphasis on the economical capture of motion, an emphasis that disregards the experience of generating performance. In the next chapter, Language, I examine the language of motion capture alongside the language of training and technique. The stabilisation of language use and vocabulary contributes to a preparedness to undertake performance capture, and enables a sense of ‘common knowing’ in the MoCap studio.

Chapter Two

Language

Language

This study has identified that there are many languages and vocabularies at play when working in a motion capture studio. These languages are determined from the personal and professional histories of the participants in the room; the inherited language that motion capture has taken from animation, theatre and film; the particularly focused language that belongs to the motion capture space; and, finally, the language of translation that inserts itself into the spaces arising between all of these competing discourses. Identifying the languages that present themselves in the MoCap studio contribute to an interrogation of the processes used to capture performance and expand our understandings of performance capture. This chapter interrogates the various languages arising through the three workshop cycles, focusing in particular on three languages central to the performance capture landscape. These are: the languages of inherited training and experience performers and other creatives bring to the workspace; the language and translation particular to the technicity of motion capture as an interdisciplinary medium; and the language of performance capture, devised and developed in tune with the progress of this study. The term language is applied as a mode of communication emerging from 'a particular community', the community of MoCap, performance and PeCap. With communication at its root it is additionally applied as a term that contributes to active translation between communities, accommodating the necessity for different performance, creative and technical traditions to work together in the foundational nature of PeCap.[16] Establishing language as a key domain of understanding contributes to a revised approach to performance in both physical and virtual space. It expands our appreciation of the field of PeCap and makes a significant contribution to the scholarship of performance generally.

An interrogation of the practical workshop series revealed various layers of

[16] Taken from the OED definition of the term language "The system of spoken or written communication used by a particular country, people, community, etc., typically consisting of words used within a regular grammatical and syntactic structure" (OED online acessed 16th April 2014).

performative language, including the performer's individualised training and preparedness; how the participants in the workshops responded to the language of motion capture; and the shift that occurs after the establishment of 'common knowing' in the capture space. A common understanding of language is that which is 'spoken' (involving the language of hearing) and that which is heard (Gourhan 1993,195). These are vital distinctions in the interrogation of language in the MoCap space, where there may be several languages articulated at any one time. These competing languages include the language of animation, the language of performance and the language of technical operation.

This research suggests a revised notion of the technique of direction, operation, performance and animation as a necessary part of the transformation from motion to performance capture. The term 'technique' is applied within this study as the formal or practical aspect of any art or occupation alongside the practical skills isolated to that field. It is with this in mind that we consider the formal or practical aspects required to successfully execute PeCap; explore the language a director, operator and performer may need to bring to a MoCap space; and how inherited technique may limit the performer's ability to perform in the MoCap environment. The redefinition of performance capture is informed by an established understanding of the technique that has emerged from theatrical, film and animation histories. The connection between these histories (both immediate and remote) and PeCap lies in an applied approach, which takes into account the particular technological conditions of the stage, film and cartoon.

Workshop Technique

Notions of technique, as a language, particularly of generating performance, emerged in different ways during the workshop series. At its simplest there were five competing techniques at work in this study: my own personal technique, the technique of the operator of the system, and of course the technique(s) of the three sets of performers. The performance techniques in this study come from traditions that are unique to each other. While all have performance at their core,

the Victorian College of the Arts in Australia, the University of Tampere in Finland, and the independent theatre scene in New York develop performance in different ways. When these modes of performance and operation are examined in tandem with the language of MoCap they contribute to the early stages of a common language for performance capture.

The actor-training course at the Victorian College of the Arts (VCA) provides a solid foundation for actors to enter the funded State Theatre Company model in Australia. Throughout the course of their degree, actors are exposed to a variety of training methodologies that prepare them for the staple fare of these sorts of institutions. Invariably they are exposed to a significant amount of work from the anglophone canon, particularly texts and performance styles from the Elizabethan, French, American and Russian traditions with a technique focus from the Lecoq and Stanislavsky Schools. There is not much attention paid to the generation of new work, and throughout the degree program they work predominantly with professional directors from the sector. There is little to no formal exposure to environments like motion capture, limited contact with filmmaking and almost no collaboration with other training institutions.

Fig 17: Lachlan Woods and Mike Steele from Workshop #1 Deakin Motion.Lab (image M Delbridge 2010/11)

At the University of Tampere students are exposed to a significantly different training approach. As is to be expected, the texts they work with tend to originate in Germanic or Scandinavian traditions. There is a predominant focus on the physicality of performance, as opposed to the privilege given to performance of the voice in the Western tradition, and they have little to no practical experience of plays from the Elizabethan period. Where the VCA has little to no exposure to the hyper-mediated, students from the University of Tampere are exposed to the widest variety of forms, from contemporary filmmaking techniques, through virtual studio production environments, to the ongoing generation of their own work. There is an incredibly vibrant collaborative approach to the sector in Finland (due to the relatively small size of the industry), where institutions work very closely with each other on projects, sharing intellectual property and physical facilities openly.

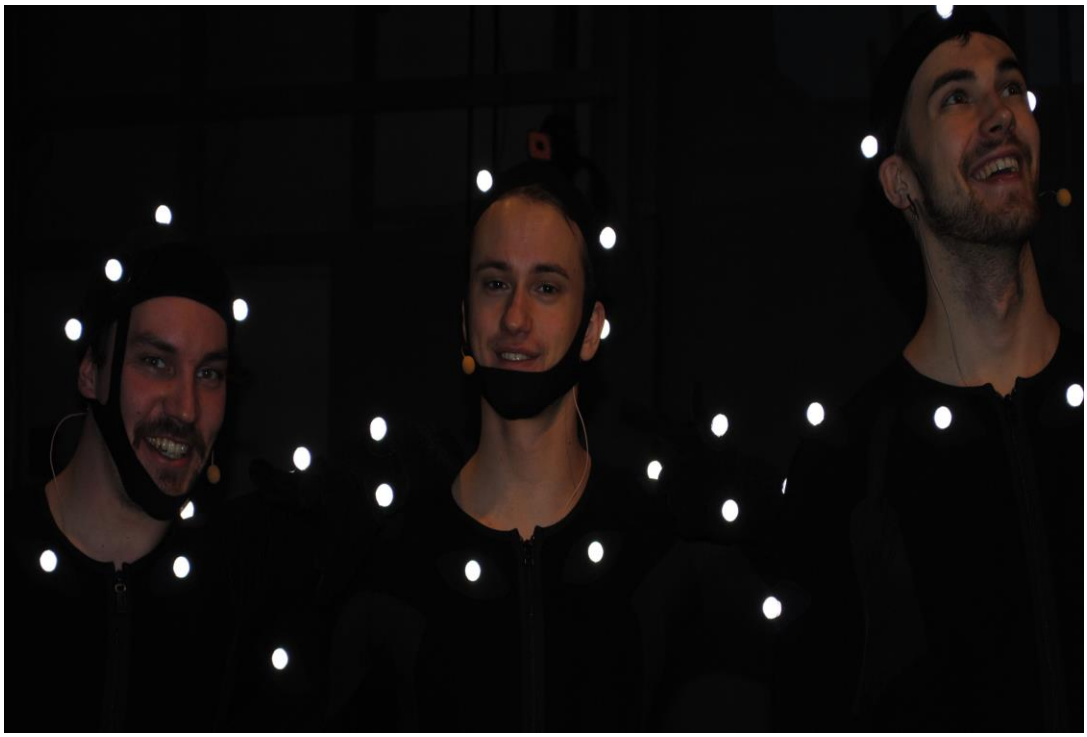

Fig 18: Haataja, Holkko and Ohtonen, LUME Workshop #2 (Image M Delbridge 2012)

Lois Weaver and Peggy Shaw came to the study with no particular recent formal training from any institution; they did, however, come with a performance tradition they had developed together over the last thirty years. While both are currently based between London and New York, during their careers they toured extensively throughout the world with their own devised works and bring to a motion capture studio a particular technique and style that has been completely influenced by this experience. If they could be classified to any tradition at all it would be to a mode of performance that rebels against formulaic traditions. They continue to teach in the academic sector, facilitating particular performance-making workshops, work as artists-in-residence at institutions, and have an innate understanding not only of current performance trends but also of the history of modern performance forms. Due to the contemporary nature of their work and practice they were well versed in hyper-mediated performance and brought a unique Off Off Broadway approach to the performance capture Space.

Fig 19: Weaver and Shaw Deakin Motion.Lab Workshop #3 (image M Delbridge 2012)

The Technical Director and Operator for all three cycles, Daniel Skovli did not come from a performance background. The particular inherited language that he brought to the capture space is traditional computer animation, and it is common for this to be the dominant language in motion capture environments. The language of computer animation aligns with the language of motion capture; however, the language of the contemporary animator is not at all connected to the language of performance or actor training. In unpacking this language dilemma, an ongoing translation remained between the operator of the system

and the performer being captured. While, for the most part, the language of the medium was native to the operator, the distinct lack of nativity of the language of performance was in constant need of translation. I explore the operator dilemma in more detail later in the thesis.

My own inherited language and experience was essential in the connection of these three test groups to the language of MoCap. Having received preliminary training in my undergraduate degree at Rusden, in a variety of performance styles, and early professional experience with avant-garde Australian practitioners like Barrie Kosky and Michael Kantor, I was well versed in both the VCA model and the Germanic tradition. I also had the benefit of a study tour to the Academy of Theatre, in Helsinki, in 2005 and an ongoing professional collaboration with the work of both Lois Weaver and Peggy Shaw outside of this study. In addition to this, I managed the central operations of the Deakin motion.Lab between 2006 and 2008. My own professional technique developed over 20 years in the theatre, and my ability to translate between the specific languages of all three groups (or four with the operator) is a fundamental aspect of the language throughline of the study.

Across all three groups of actors there was a genuine interest in the technical language of MoCap and how this language would become a part of the lexicon of performance. There was a desire, particularly from the younger actors, to gather an intimate understanding around how the technology worked. In the first workshop this necessitated an ongoing translation from both me and the operator, where we consciously deployed and defined the language of both MoCap and PeCap. In this workshop I maintained an internal anxiety around ensuring every term, including its origin, was explicitly explained. In the second workshop, in Finland, however, there was considerably less explanation given as to the origin of the terms used. While this necessitated a constant request for clarification on certain terms, I remain unsure whether this was due to native language translation (i.e. English vs. Finnish), a barrier in the training methodology

received thus far (final year students), or that the technicity of the motion capture Language needed further clarification. In the third workshop, neither participant expressed a desire to know ‘how’ the system worked but were comfortable with the knowledge that it ‘did’, and very quickly adapted to the language that was being deployed around them (i.e. volume, T-pose, template). In the approach to this workshop, we chose not to explain the terms central to the process and comfortably deployed the language of the medium, a language that the operator and I understood natively. I would contend that this lack of anxiety around terminology had a calming effect in the capture cycle. Again, this is an area for further research.

All three groups performed excerpts from an Elizabethan text on a 3D model of the Rose Theatre. As expected, the actors from VCA did so without anxiety, and were inherently prepared to do so. Not only with the text they were asked to learn, (both were tasked with the last soliloquy from Marlowe’s *Faustus*), but had many other memorised speeches they could draw on to provide alternate captures. The Finnish actors found that the language and translation dilemma additionally complicated the process. They were working in a non-native tongue (English is their second language). While they were similarly tasked with learning an Elizabethan text (this time of their own choosing), and arrived for the capture cycle with the text learnt, they were not experienced with the performance tradition of Shakespeare and were obviously ‘native’ in their approach. This was an important aspect of the study, where a necessary amount of time was spent translating the text so they understood what they were saying in the act of performance. In workshop one and two, discussions on authenticity, that is to say what might constitute authentic performance on an Elizabethan stage, and the approach to language became central. This research contends that the language of technique is amplified by the presence of the simulated ‘authentic’ 3D venue, The Rose Theatre. In the third workshop, neither performer had performed Elizabethan text before and articulated no particular interest to develop any expertise or authenticity in the area. This was inconsequential to the capture, but

vastly different to the other two workshops. In the performance of the Shakespearean text, we placed a copy of the text in large font on the major feedback screen next to their feedback loop, this enabled confidence in the language and removed the need to recall a ‘language’ that is essentially foreign to the performers. Figure 20: Peggy Shaw streamed to The Rose Theatre (Delbridge 2012), illustrates the text presented on the feedback loop screen as part of the capture.

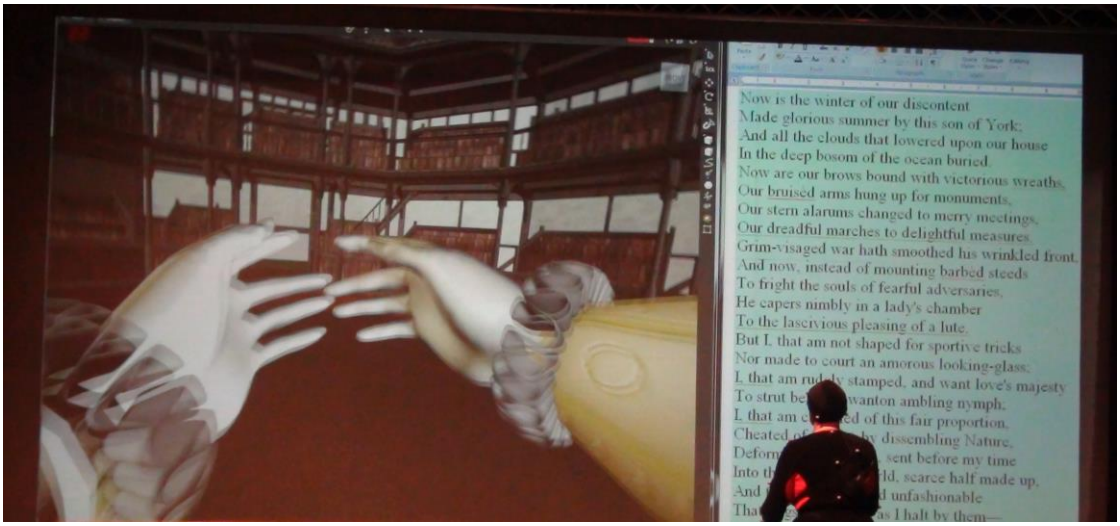

Fig 20: Peggy Shaw Streamed to the Rose Theatre via MotionBuilder with text from Shakespeare’s Richard the third projected as prompt (Image M Delbridge 2012)

Translation

To undertake this reflection on language use it is essential that there is an observer in place “operating from a particular frame of reference, within a particular time, place and cultural framework” (Patton and McMahon 2006, 180). As I occupied the position of researcher, participant and observer, my particular frame of reference was as much concerned with translation as anything else. This notion of translation was an ongoing theme through the study, where several variations of language were present throughout the three workshop cycles. The following section discusses these variations and the successful construction of a common language emergent across all three. This sense of common language is essential to the development of knowing, where “language is the vital influence on the perception and description of reality” (Patton and

McMahon 2006, 181). The language of motion capture is described here and points toward its historical connections in related terminology from theatre and film. An applied sense of motion capture terms is a central component of the preparation for the director, performer and operator to translate into the technique of performance capture.

For the most part, the practical language of theatre in the performance venue has remained relatively unchanged over the last twenty years, with the last widely distributed texts on theatre terms and their deployment to be found in Lounsbury's *Theatre Backstage from A to Z* (1989) and Nelms *Scene Design - A Guide to the Stage*, (1975). Unpacking the 'new' language of current professional performance environs is key to establishing integration into motion capture studios. The importance of the relationship of language to this study is in the generation of common understanding derived from a developed sense of shared 'knowing'. For this reason, the establishment of a common language is an integral part of the performance capture workflow.

In order to establish a common language, it is essential to isolate terminology that is particular to motion capture. This next section includes a breakdown of the traditional marker set and a description of the movements and poses deployed as part of the integration of performance into the MoCap system. This is the language of motion capture; terms commonly understood by all participants in the studio, a language composed of a body of terminology existing outside the formal experience most directors and actors encounter. For the purpose of clarity, nine discrete terms crucial to a workable understanding of the capture space are defined. These terms are: motion capture, performance capture, marker set, calibration, t-pose, range of motion (ROM), template, capture volume and frame. These terms come from the commonly used and understood lexicon of MoCap and are presented here as a foundation for the introduction of MoCap language to the lexicon of performance, and a foundation language for PeCap. While these terms can be found in various aspects of the literature available (Kitagawa and

Windsor 2008, Tobon 2010), the particular definitions and their combination together are devised as a direct response from my own professional experience and the practical aspects of this study. They are presented as a set of terms vital to understanding the technical nature of performance in a MoCap studio and a cornerstone of the necessary communication between operator, director and performer undertaking PeCap.

Motion capture (or MoCap) describes the process of digitally recording movement in 360 degrees and translating that movement onto a model in projected or screen-based 3D space. While it borrows from traditional filmmaking, its major distinction is that it does not record what would be traditionally referred to as the framed moving image (the translation of the 3D to the 2D) but more accurately records an accurate impression of plotted movement in 3D space that can be transferred to a screen-based 3D impression. There are several modes of motion capture, with device types best grouped into two distinct forms: optical motion capture (passive, active and marker less) and non-optical motion capture (magnetic, inertial and mechanical). This project uses a passive optical motion capture system as it is the system type most often deployed in the commercial animation and filmmaking sector. It allows for several objects to be captured at once and provides the greatest accuracy.[17] While MoCap is used extensively in military and biomedical applications, it is the terminology of motion capture in creative applications that are defined here. In filmmaking it refers to recording actions of human actors, and using that information to animate digital character models in 3D animations to be used in computer generated imagery (CGI). When the capture includes the entirety of a complete performance (not just functional movement), it is referred to as *performance capture*.

[17] The Motion Analysis system used in this research is the Rolls Royce of motion capture systems, there are several other optical systems available that range in cost from a few thousand to hundreds of thousands. The two 24 camera Motion Analysis systems used here cost in excess of $500,000 (including suits, markers and software workflow)

In *performance capture* an optical MoCap system is most widely used, as this is the most accurate tool that allows for multiple objects, actors and static props to be captured at once. Passive optical systems remain free of external wires as the potential wireless corruption of devices can limit the movement and performance of the actors or corrupt a complex stream of data. An optical MoCap system is composed of a camera array of between 3 and 300 cameras where each emits a near infrared lighting source. This source is used to bounce off a group of markers coated in reflective tape attached to the capture subject. These reflect light back to the camera. Through a process of *calibration* and adjustment the camera array is manipulated (both physically and through a software interface) so that only the reflective markers are tracked in a capture volume. An L-frame, with markers attached at positions that replicate the cartesian coordinates of the X, Y and Z-axes alongside a calibration wand, is used to calibrate the camera array. This provides the system with each camera's relative position and an individual measurement of each camera's lens distortion. Providing two calibrated cameras see a marker, a 3 dimensional fix of that marker in space can be obtained.

The greatest benefit of optical MoCap is that the *marker set* (the attached series of rubber balls with reflective tape on the figure) is then translated into screen space without the encumbrance of cables and wires to inhibit or limit the performance of the object. Markers can be attached directly to the skin (as is often the case in biomechanics), or they are velcroed to a performer wearing a full body lycra/velcro suit constructed from a double stretch fabric specifically designed for the industry. The marker set is the group of markers allocated to and placed on the human figure or object in a motion capture environment. Traditionally, a human figure would have between 35–50 markers at designated areas to create a template to drive a digital skeleton in an avatar. The marker set requires uniform placement, depending on the software and system being used (detailed in Figure 21 standard marker set shown from four angles and Figure 22 Marker Set table).

Fig 21: Standard marker set shown from four angles (image Simon Fox 2006)

Head	Shoulders	Arms	Hands	Back	Legs	Feet
1. LFHD: left front head	6. LFSHO: l left front shoulder (clavicle)	12. LUPA: middle of left upper arm	20. LTHUMB: base of left thumb	24. Top Spine: top of the spine	34. LTHI: outside middle of left thigh	43. LHEE: left heel
2. RFHD: right front head	7. RFSHO: right front shoulder (clavicle)	13. LELB: left elbow	21. LPINKY: base of left pinky	25. Mid Back: on spine where the ribcage ends	35. RTHI: outside middle of right thigh	44. RHEE: right heel
3. LBHD: left back head	8. LRRShould: left shoulder blade	14. RUPA: middle of right upper arm	22. RTHUMB: base of right thumb	26. STRN: centered on sternum	36. LKNE: outside of left knee	45. LTOE: left foot just before big toe starts
4. RBHD: right back head	9. RRShould: right shoulder blade	15. RELB: right elbow	23. RPINKY: base of right pinky	27. Root: the base of the spine	37. RKNE: outside of right knee	46. RTOE: right foot just before big toe starts
5. ARIEL: top of the head	10. LSHO: top of left shoulder	16. LFRM: left forearm		28. LFWT: left front waist	38. LSHIN: left shin	47. LMT5: outside of left foot where toes start
	11. RSHO: top of right shoulder	17. LWRIST: top of left wrist		29. RFWT: right front waist	39. RSHIN: right shin	48. RMT5: outside of right foot
		18. RFRM: right forearm		30. LBWT: left back waist	40. LANK: left ankle	
		19. RWRIST: top of right wrist		31. RBWT: right back waist	41. RANK: right ankle	
				32. Pelvis: just above the waist, to one side	42. RANK: right ankle	
				33. Lower Back: just below the middle back		

Fig 22: Marker Set table (M Delbridge 2013)

Once the marker set is established, the performer completes a movement series, and the system generates a template. The *Template* is the first step in the transformation of the human performer to an accurate 3D representation in virtual space. The first of these movements is called a *T-pose*. This pose (currently adopted as the general standard) keeps all markers at a relative distance from each other to prevent marker swap in the construction of a template. The other function of the T-pose is as a device that allows markers to realign themselves as the template slowly deteriorates during a shoot (caused by a gradual loss in calibration of cameras). The T-pose has become the internationally recognised and deployed static pose for all animation and performance capture environments used for the construction of a marker data set into a recognised object or template. This physical pose is also the standard neutral character position employed in the scratch creation of characters in the CGI of biped avatars.

A *Range of Motion (ROM)* is the second of the series of movements captured that are used to 'teach' the motion capture system and related software the behaviour and movement of a particular set of markers when attached to a moving figure. The ROM begins and ends with a T-pose and is built up over 5-6 individual takes that increase in complexity in the construction of a template. IoP#2 illustrates the process of taking a performer through the ROM deployed in the practice cycles of this study (in this instance from Workshop #1 at the Deakin Motion.Lab in July 2010). The ROM used here is an adaption that has developed from the Motion Analysis standard. Notice that in this illustration of practice the operator of the system inducts the performers through this stage of the process. This was a deliberate decision taken within the workshop cycles. Daniel was responsible for the suiting, marking and templating of the performers in all three workshops, to establish an independent connection to each performer. This approach is a key aspect of the developing PeCap methodology; it privileges the relationship between operator and performer and emphasises the central aspect of the act of performance in the MoCap system. Each ROM is unique to the

individual performer and, while initially based on a prescribed set of movements, it adapts to match the individual performer's movement style and the specific characterised movement required of the character to be driven and captured. After this process, the template becomes object, and allows for the individual markers tracked in 3D space to be allocated specific relational characteristics that enable the development of a cohesive set. An object can then be used to drive/control an avatar that, in turn, drives a character.

After capturing the T-pose, the static capture is used to label a marker set and create an initial set of relationships between the individual markers. Once the relationships are established, the first phase of the template is individually named, and then used to create what is known as a more robust template using the series of ROM captures. It is this individualised template that remains unique to each and every performer and needs to be re-established at the beginning of each capture session. Simply put, the template of one day will not necessarily work as the same individual's template on subsequent days, depending on a complex set of variables linked to marker placement, performer posture and capture volume variations. While it is widely accepted and understood, the work we undertake in traditional performance spaces employs standard 3D rules. As soon as the physical 3D space is transformed into the computer generated space a higher level of understanding is required. As we translate this basic perception into mediated, screen-based or digital environments (that essentially replicate 3D space), and as soon as 'capturing' a performance or action is translated into 3D space (keeping in mind the screen is essentially a 2D environment containing only a vertical and horizontal planes), we begin to interrogate the *volume* of space that adds action to the equation.

The motion capture *volume* is the amount of 3D space the system can see. This translation of screen-based 3D space to physical space is determined by the placement and settings of the capture devices (cameras) and their distinct relationship with each other as separate units. The two-dimensional space of the

screen traditionally represented with an X (width) and Y (height) axis is challenged as the MoCap volume adds depth (or action) to the equation with this third manipulable parameter, known as the Z-axis. This three-point reference system (Cartesian coordinate system) has been universally adopted by the 3D visualisation industry and is successfully used in motion capture environments to define, display and manipulate many properties of a 3D object or character on screen, including position, rotation and scale. IoP#3 illustrates the MoCap volume and the limitation of its invisible boundaries. In this video package you will hear me explain the concept of the volume limitations to Lois Weaver in Workshop #3 at the Deakin Motion.Lab in July 2012. Watch as the neutral actor (the blue avatar) collapses into the 'origin', the centre of the volume, when Lois is outside of its limitations, and then how quickly it snaps to attach to her marker set when she re-enters.

Depending on the capture that is being undertaken, the volume will be adjusted. These variables include: the number of objects to be captured, the type of performance to be captured, and the physical properties required in the space for performers to interact with. It is worth noting that if a character needs to be captured sitting at a desk writing or climbing a rope, the most effective way to do so is to have them physically sit at a desk or climb a rope. It is only their movement in space that is recorded and not a visual image of the physical object. The establishment of the volume is an important early step in the profilmic setup, as any character or object performing outside of this volume in whole, or in part, will not be captured, or their individual template will break and turn into an unmarked data stream or cloud of ghost markers.

When performance is captured in a motion capture environment *Framing* decisions can be made during and/or after the capture. This is unlike traditional filmmaking or the staging of performance where all of these intentions necessarily need to be confirmed by the director in the production or rehearsal stage. These decisions can be made after the shoot, in several different

permutations or, indeed, by the end user, depending on the user interface. This presents a unique challenge to the director, operator and performer as there is no specified performance frame apart from a direct concentration on the actual scene.

Conclusion

The nine discrete terms selected from the lexicon of MoCap terminology form the foundation of a language for PeCap. When these terms are introduced to the technique(s) of performance they combine to generate a form of new knowledge in the understanding of performance captured in physical and virtual space. The captured data of performance contributes to a language that isn't fleeting, like a live performance, nor preserved organically and chemically, like film, but is stored immaterially in a language form known as data. This restoration of data in the virtual contributes to a material understanding of space on the screen even though it remains immaterial. It comes from the physical and disappears as code, to reappear on the screen as captured movement, or the recreation of a representation of movement. In an initial definition of space, Aristotle's *topos* (or place as the sum of all spaces) asserts that only six modes of movement occupy space in place – up, down, right, left, forward and backward. This determination of movement underpins our understanding of the geometric of space and connects to the infinite and measurable in three dimensions over time. The Aristotelian notion that there is an intimate relationship between space and movement, coupled with Einstein's connection of movement to time, suggests that a spatial discourse relevant to the capture of motion should accommodate these key principles. As the re-creation of language in virtual space is represented as a form of movement, it is fitting that this now leads us into a discussion of space, informed by the presence of movement on the screen. The captured movement that comes from the language of training, technique and experience combines in the studio space to be captured as code. That this code can then be transformed into a spatial representation of a real time capture is explored fully in the next chapter, Space and The Frame.

Chapter 3
Space and The Frame

We lived once in a world where the realm of the imaginary was governed by the mirror, by dividing one into two, by theatre, by otherness and alienation. Today that realm is the realm of the screen, of interfaces and duplication, of contiguity and networks. All our machines are screens, and the interactivity of humans has been replaced by the interactivity of screens.
(Jean Baudrillard 1993, 54)

Space and the Frame

The act of performing in the duality of physical and virtual space in performance capture is best explored through practice in the studio. When underpinned with relevant theoretical models, this view of practice contributes an additional layer of understanding to PeCap, particularly in the replication of physical space, visualised as three dimensions for the screen. The theoretical models I refer to come from Edward Gordon Craig (1907); Oskar Schlemmer (1924); Gaston Bachelard (1958); Henri Lefebvre (1991); and Jean Baudrillard (1996). I have selected aspects from the work of three of these theorists, suggesting they be viewed as primary sources to establish the spatial and framing foundation for a twenty-first century approach to PeCap. These are *Man and Art Figure* (Schlemmer 1924,1961); *The Poetics of Space* (Bachelard 1958); and *The Production of Space* (Lefebvre 1991). In addition to these three primary sources, I deploy Craig's *The Über Marionette* (1907) to provide a historical lineage to the concept of virtualised performance, and Baudrillard's *Clockwork Man* (1996) to inform an examination of the *simulacra* and the *simulated*'s contribution to a practical understanding of PeCap. This spatial discourse is examined and informed by practice in the MoCap studio, connecting the performer to a screen-space version of themselves. It contends that two significant notions of PeCap, Space and the frame, reveal an approach to performance for omniscient capture that may resolve the dilemma of performance in physical and virtual space.

Schlemmer and Cubical Space

There is a clear connection between the analysis of space undertaken by Oskar Schlemmer and the division of space facilitated by a motion capture camera array. This understanding comes from Schlemmer's interrogation of the Laws of Cubical Space (1924) presented in *Man and Art Figure,* from *The Theater of the Bauhaus* (Gropius and Wensinger eds.1961). In Schlemmer's laws, the dialogic between the soft lines of the organic human body is set against the hard lines of that which is measurable, the cubic aspects space. Schlemmer's work is concerned with the laws of order governing cubical abstract space and how

these laws can be manipulated when compared to the organic laws of the human form (Schlemmer 1924 in Gropius 1961, 22, 23). Figure 24: *The Laws of Cubical Space*, (Schlemmer 1924) illustrates the “invisible linear network of planimetric and stereometric relationships” that govern a space (Schlemmer in Gropius 1961, 23):

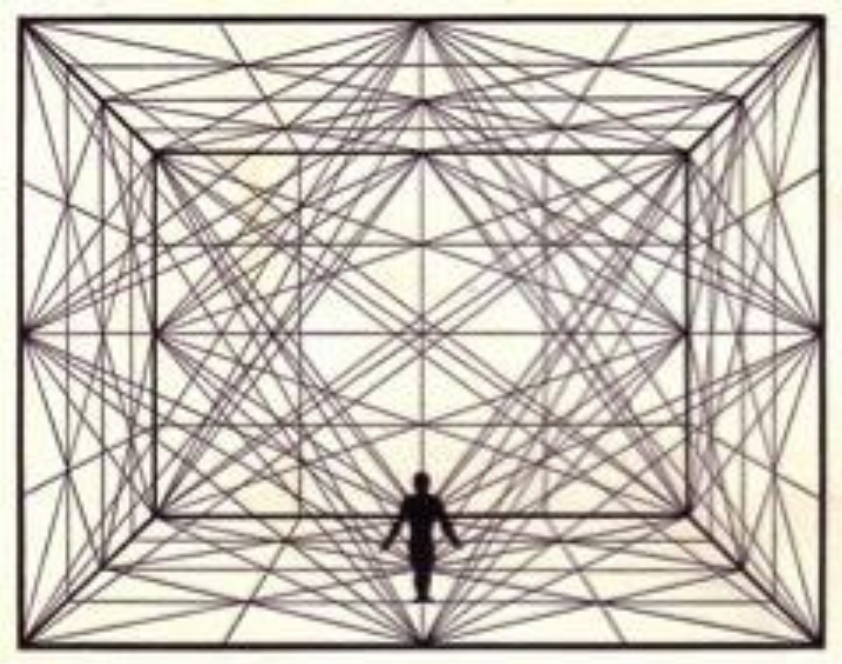

Fig 23: The laws of Cubical Space, Oskar Schlemmer (Image O Schlemmer 1924)

This frame provides a means of identifying both the volume of a focused motion capture system and the camera array that tracks markers in the environment. Schlemmer’s laws of cubical space serve as a useful illustration to introduce the performer to the capture environment. In his image of cubical space, Schlemmer depicts the actor standing in the centre of a performance volume in a neutral ‘A’ pose. When placed alongside an image of the rays from the motion capture system’s camera array, the likeness in the coverage of space, essential to the calibration of the motion capture system, becomes very clear. Figure 24: Cubical Space alongside Cortex image from Motion Analysis Camera Array (Delbridge 2013) provides a comparison of Schlemmer’s cubical space with the focused camera array of the optical MoCap system. They are very startlingly similar,

especially where the “mathematic corresponds to the inherent mathematic of the human body and creates it’s balance by means of movements, which by their nature are determined mechanically and rationally” (Schlemmer, in Gropius 1961, 25).

The rationale governing movement of the organic in the cubical space leans towards a transformation of the body. It emphasises mathematical properties, and highlights the potential to measure and plot movement in space.

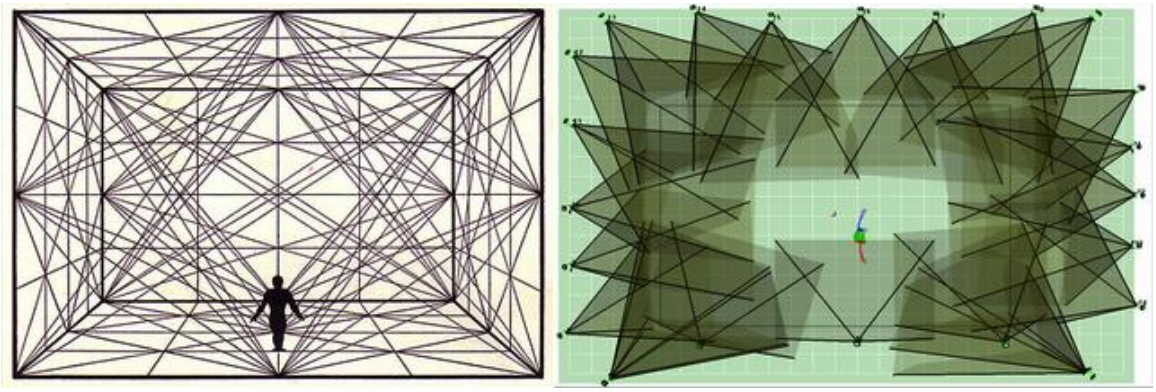

Fig 24: Cubical Space alongside Cortex image from Motion Analysis Camera Array (Image M Delbridge 2013)

Schlemmer was concerned with the spatial clash of the organic versus the cubic in the theatre. The motion capture environment approaches the problematic in the same way. It captures the dimensions of the organic figure in space and transforms it into a mathematical (or cubical) representation. Schlemmer’s response to the laws of organic man in the inorganic environment centres around two notions: the *Kunstfigur*, the mechanical human figure; and the “native costume” (Schlemmer 1961, 29).

Schlemmer’s native costumes were used as a representation of the characteristics of the ‘everyman’ and as modes of integrating the hidden human form into the essential attributes of theatre and performance. These essential attributes for Schlemmer were facilitated by a performance mode known as *Tanzermensch* (‘man as dancer’). The facilitation of integration ‘into’ space was achieved through the organic as it is transformed into the inorganic via costume and movement. This transformation is replicated in the representation of the

human figure in the Motion Analysis capture software environment Cortex and the The Shakespearean actor avatar (SAA) streamed in MotionBuilder.

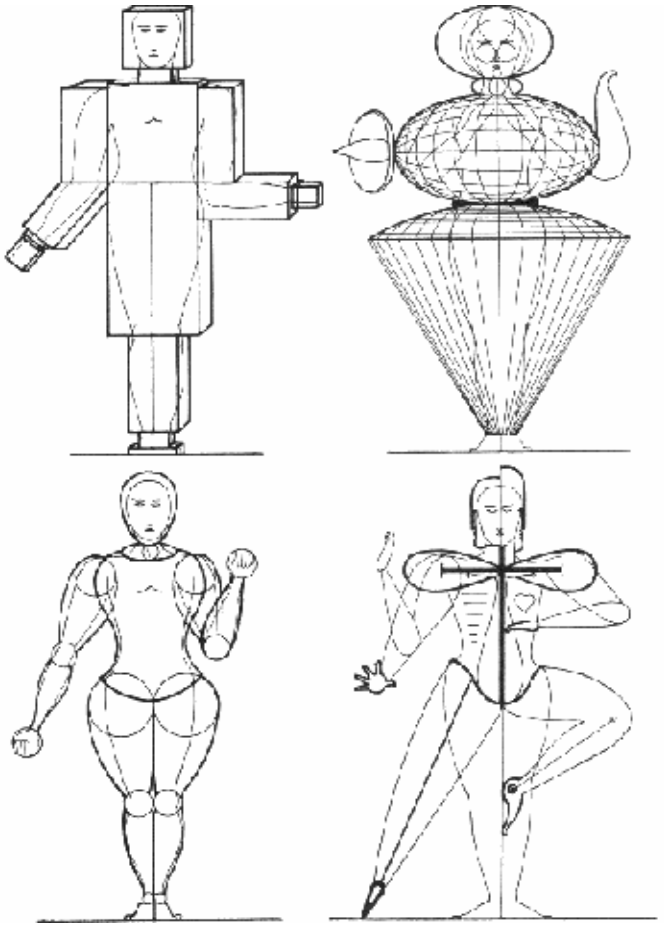

Fig 25: Native Costumes for Triadic Ballet (Image O Schlemmer 1931)

Schlemmer's explorations clearly articulate the complexities of MoCap and show their centrality to the spatial discourse that underpins the practice of performance capture. His vision of the dancing man as the most appropriate form to occupy cubical space connects to the primary aspect of performance captured in motion capture – movement. The translation in the studio from physical space to the virtual is facilitated by costume, the motion capture suit covered in retro-reflective markers that determines the abstract cubical representation that drives the neutral in screen space. The SAA, the templated figure driven by the actor in MotionBuilder, occupies a similar spatial dimension (with its own set of

parameters to be observed in the translation from the physical to the real), and further reinforces the connection between physical and virtual space.

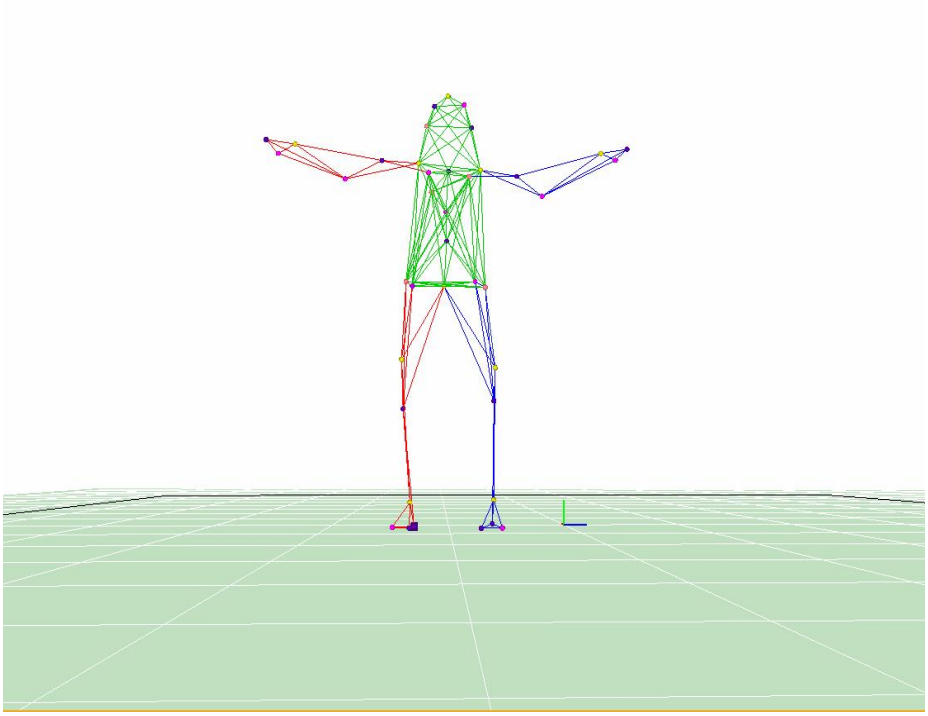

Fig 26: Templated figure in *Cortex* motion capture Software (Image P Divers 2013)

Figure 27: Native Costumes from Schlemmer, Templated figure from *Cortex*, shakespeare actor avatar (Delbridge 2013), offers an illustration of the comparative transformative aspects of all three modes of costume that render the performers occupation of space from organic to mathematical form. The first image represents Schlemmer's native costumes, the second the Cortex template from the capture software, and the third the SAA that the performer drives in the previsualised Rose Theatre. When the three images are combined in this single figure it is easy to see the connection between the spatial transformations of costume central to the work of Oskar Schlemmer and how costume can occupy a similar sense of space in the virtual when working with PeCap.

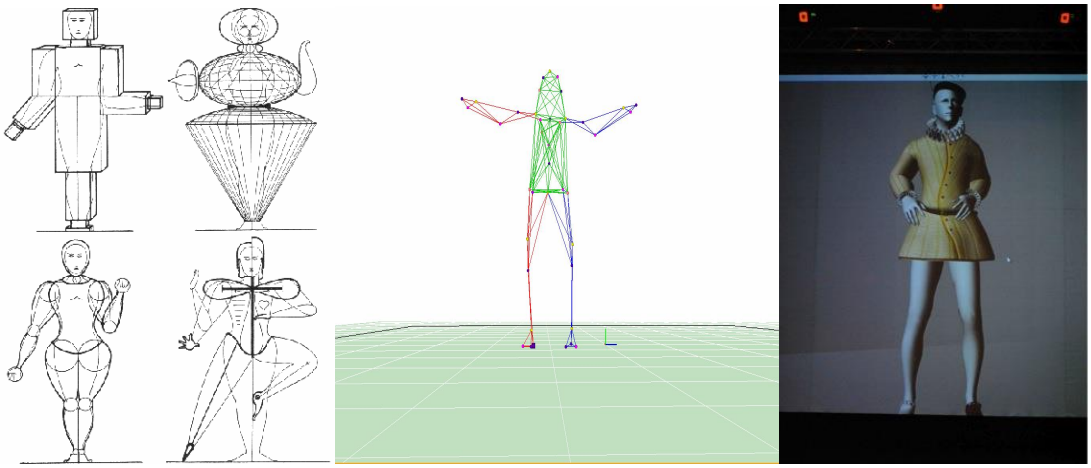

Fig 27: Native Costumes from Schlemmer, Templated figure from *Cortex*, Shakespearean actor avatar (Image M Delbridge 2013)

IoP#4 offers an insight into the driving of the SAA from Lachlan Woods, one of the actors from the first practical workshop at the Deakin Motion.Lab in July 2010. In this package, Lachlan is 'rehearsing' on a 3D model rehearsal stage based on the dimensions of the Rose Theatre and discusses the relative scale of the SAA compared to his own frame. The challenge in the driving of this avatar is that the costume occupies space on the screen that doesn't match the space that Lachlan's costume, the MoCap suit, occupies in physical space. This particular discussion is concerned with the ongoing issue of the muscle memory required to stop his hands passing through the tunic of the SAA. To counter this, foam rolls were rudimentally attached to his upper thighs to replicate the relative size of the ballooning tunic. This enabled Lachlan to concentrate on the performance and not the constant breaking of the characterised avatar. See Fig 28: Foam rolls added to MoCap suit to replicate space occupied in virtual space by the 'virtual' tunic of the SAA.

Fig 28: Foam rolls added to MoCap suit to replicate costume space occupied by SAA tunic
(Image M Delbridge 2011)

In 1907, Edward Gordon Craig developed a theory of performance that influenced Schlemmers' *Kunstfigur* and *Tanzermensch* (1933) and which enhances our understanding of the templated subject in the capture environment. In his essay, *The Actor and the UberMarionette* (1907), Craig alludes to the nobility of stone carvings and the necessary return to the ancient male mask. This mask is unburdened by human emotion and idol dreams, but blank enough to receive instruction and control from a constant and present master. I contend that a contemporary version of Craig's mask exists in the workflow of PeCap. This driving of the ancient is facilitated by the motion capture suit and enables both movement and performance through spatial integration. Craig asserts "the body of man is by nature utterly useless as a material for art" (1907 84). In arguing this, he implies a future form of performance that will allow the 'everyman' to populate the spaces of performance in a return to modes of representation of a time where there were only stories of 'everyman'. He maintains that actors will continue to hinder the development of the theatre "impersonating and interpreting" and tells us they "must create for themselves a new form of acting" (ibid). Craig is at times misread by those who would suggest all actors must be done away with and replaced with the automaton (the automaton and robot is discussed further later in the chapter, through Baudrillard). More accurately, what he suggests (or predicts) is closer to the manifestation of an obedient puppet, or in motion capture terms, the 'object' the actor drives in virtual space (see Figure 26, p85). He suggests "there is something more than a flash of genius in the marionette, and there is something in him more than the flashiness of personality" (Craig 1907, 86). This abandonment of personality is precisely what occurs when the actor moves in physical space and drives the marionette in screen space. Performance capture reveals the manipulator, and with this has returned the marionette to a pure state. The enabling nature of the suit is connected intimately to Craig's notion of the marionette and Schlemmer's abstract native costume in cubical space.

Bachelard and Roundness

The second spatial lens useful to the study comes from Bachelard, and relates directly to the potential of performance captured in a capture volume. Bachelard asks us not to reduce our definitions of space to the limited view of the geometer, suggesting that the space of roundness is central to measuring humanity. For Bachelard "being is round" (1958, 234), and this roundness of truth, as taken from *The Poetics of Space* (1958), supports the global capture facilitated by a MoCap system. Within this godlike frame, "images of full roundness help us to collect ourselves, permit us to confer an initial constitution on ourselves, and to confirm our being intimately, inside" (ibid). Bachelard relates the spatial properties of the round to the centre, and in omniscient framing, the performer maintains the position of centre in the capture of performance:

> we find ourselves entirely in the roundness of this being, we live in the roundness of life, like a walnut that becomes round in its shell. A philosopher, a painter, a poet and an inventor of fables have given us documents of pure phenomenology. It is up to us now to use them in order to learn how to gather being together in its centre. It is our task, too, to sensitise the document by multiplying its variations.
> (Bachelard 1958, 234)

Identifying the precise centre of the capture space is a vital aspect of MoCap, as this position is used during various stages of a capture. Some of these stages are: the establishment of the capture volume; the initial positioning for an object's template; and the initial stage of templating the performer. It is also used as a return position to the loci of space at subsequent stages during a shoot, when a performers template begins to slip.[18] The PeCap director develops an intimate relationship with the centre point of the capture space, and from this position establishes the boundaries of the performance with the performer.

[18] During a capture session a performers template will begin to degrade in quality due to the calibration of the MoCap system. This degradation is caused by many factors, the heat in the room, the MoCap suit moving slightly, scuffs that appear on the floor. It is not uncommon to recalibrate the MoCap system in the middle of the day to accommodate this.

By working within circular space, we are able to prioritise the concept of the centre. This is fundamental to the performer's understanding of the performative space they occupy. By placing Bachelard's assertion that "being is round" (ibid) into the act of direction and performance in PeCap we ensure what is captured is a complete performance. Performing with a working knowledge of Bachelard's circular space allows for the limitless variations available for viewing in the post capture of performance to be undertaken. In the theatre space, a degree of distance is maintained between the action (on stage) and the viewer (the audience in their seats).[19] In film, the frame determines how a performance will be read, and there is always a distance between the projected image on screen and the viewer. In the capture of performance in PeCap these traditions are challenged. The performer is at the centre, the viewer can potentially exploit an infinite number of proximities and the roundness of the captured performance, focused from the centre out, must accommodate this.

In the workshop series, the notion of the circular was amplified by the performers' navigation of, and performance within, the model of the Rose Theatre. The Rose is a circular venue similar in nature to The Globe, but with a smaller stage area that amplifies the cylindrical nature of the space. In the performance workshops this facilitated exploration of the cylindrical nature of the model, enhancing the spherical nature of the 360-degree capture frame and the architectural challenges of the venue. The Rose Theatre was introduced as the third stage of each workshop and provided the participants with a multitude of navigation challenges (examined further in Chapter 5).

Two modes of spatial and performative exploration emerged in the workshop in Helsinki where the larger capture space enabled greater replication of the physical dimensions of The Rose. This did not occur in workshops one and three, as the Deakin Motion.Lab can only accommodate half the 'stage' area and I only

[19] I preface this assertion by referring to the traditional relationship between the audience and the stage in theatre and not modes of performance that challenge the performer/audience relationship such as postdramatic performance. See Hans Thies Lehmann *Postdramatic Theatre* (1999)

explored solo performance scenarios. In Helsinki, each performer could respond to the explorations of the other both on the floor and through the screen image generated by the presence of a virtual camera placed within each performer's marker set. The virtual camera was used as an exploratory and performative device during all three cycles of the workshop program (not just Helsinki). When the presence of three screen-based perspectives generated three individual perspectives of the venue, this challenged the singular nature of the centre.

The virtual camera is central to two modes of circular exploration undertaken in the workshop series. The first mode concentrated on solo performance (single camera) and the second on group performance (multiple cameras). In the foreground of Figure 29: Virtual cameras mounted into marker set Helsinki (Delbridge 2012), you can see the virtual cameras revealed in the SAA on the screen. One is highlighted in green in the centre of the screen, and the other on the right hand side sitting at the top of the revealed skeleton of the SAA.

Fig 29: Virtual cameras mounted into marker set Helsinki (Image M Delbridge 2012)

Single Camera Exercise

The single camera exercise is a technique deployed in all three workshops. In the exercise, a virtual camera is placed within the upper chest of the subject to generate a perspective in screen space. This transplants the performer from the 3D environment onto (or into) the screen with a perspective aimed to replicate the 'vision' of the object. Through various incarnations of camera placement the chest emerged as the most stable camera position as it provides the least amount of movement. When the camera is placed on the head marker, for example, the screen environment constantly shifts, giving the performer motion sickness from their interaction with the screen. While it may seem that the camera perspective is best placed above the neck, the amount of movement generated from this position is remarkable. This could become a powerful tool for a director to instill 'stillness' in a performer, but is not useful in the navigation of screen space. In Figure 30: Virtual camera mounted in marker set manipulates image on screen (Delbridge 2012), the background screen shifts with minimal movement of the actor as they seek a mode of performance that can connect with the upper balcony of The Rose. This mode of delivering text to the various audience areas of the venue was used as a directing exercise in all three of the performance capture workshops. The single mounted camera encourages the actor to locate all five audience areas of The Rose Theatre in virtual space: the groundling area (the ground), the three balconies and the Lord's box at the back of the stage. IoP#5 demonstrates this concept in action from the second workshop cycle in Helsinki. Note how the theatre environment shifts as the performer, Aleksi Holkko, moves from lying to sitting on the stage of the rounded Rose Theatre. While The Rose Theatre accentuates aspects of roundness in screen space, this is also replicated by the sperical nature of the frame provided by a MoCap system.

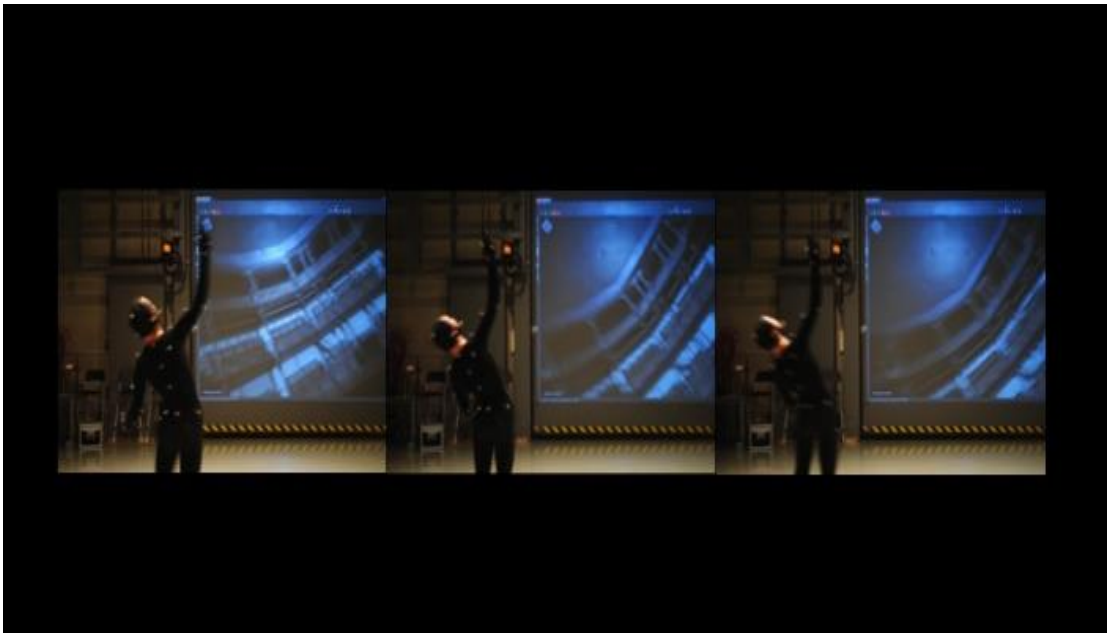

Fig 30: Virtual camera mounted in marker set manipulates image on screen (Image M Delbridge 2012)

The Frame

To provide context around framing in MoCap it's useful to use the more commonly understood concept of the frame from film. The neutrality of a chosen pictorial frame (as manipulated by early manual camera focus), or a particular capture frame rate (as manipulated by early manual camera handles), or even capture time available (as dictated by the physical footage of film able to be carried in the camera) is only brought into question in motion capture after the movement has been captured. The truly impassive document that records a performance assumes a frame, focus and length of record that remains impartial. The standard frame capture rate (or frequency) deployed in film: that is the rate at which individual frames or images are captured consecutively; is 24-30 frames per second (or fps). An individual motion capture camera deployed as part of a MoCap system (that may involve up to 100 individual cameras) in a dedicated network or array captures at a standard rate of 250 fps. If we consider the first mechanised silent film camera captured performance at around 16fps, this begins to contextualise how much performance is captured when the rate of capture is many times greater. This is especially the case when the frame is not limited by the restriction of the window.

The Omniscient Frame

Devising an approach to framing in virtualized space contributes a critical dimension to an ongoing dilemma in acting and performance initiated at the beginning of the twentieth century. This dilemma can be pinpointed specifically to the actor being confronted with the capture device, and recorded, leading to representations and mechanised reproductions of performance being distributed and screened. Twenty-first century technology has amplified the impact and potential of this reproduction in the digital. As the capture device has grown to levels of extreme sophistication and efficiency, it is now not only voice and image that are captured but also the plotted movement of performance. The entirety of this capture is recorded as a data stream through a frame I have termed in this study as *The Omniscient Frame* (Delbridge 2012). This revitalised frame is enabled by the capacity of a motion capture system's camera array to see within a volume, to capture not just the height and width of the 2D frame, but to capture depth (via movement) as well.

I contend that *The Omniscient Frame* is the primary mechanism employed in the capture of live performance for filmic, game and theatrical production, using a MoCap system. It is the framing device that performance is recorded within; it is a global frame, not hindered by the formally understood notion of the 'window' typified by the cinematic frame. It includes the volume of space where the recording took place, enabling performative intentions to be negotiated after the performance is captured. This concept of a framing mechanism that captures performance globally reconceptualises our understanding of the played intention of performance.

When performance is captured in this environment, depending on the capture volume (the space in which the performance is captured), all framing decisions can be made both after and/or during the capture real time. In traditional filmmaking, these intentions need to be confirmed by the director in the production or rehearsal stage, or the staging of performance, but in the

omniscient capture of performance, decisions can be made after the shoot. *The Omniscient Frame* revolutionises our understanding of performance generally, and reclaiming performance capture as a medium is inextricably linked to this understanding. Within the practical and philosophical discourses of motion capture it is fitting that this term and the potential it offers performance be incorporated into the working principles of PeCap.

The MoCap system and its capture of the movement of a group of markers replicates the movement of a subject in a screen-based version of three dimensions, allowing for all framing decisions to be achieved during and/or after the capture event. This presents a unique challenge and paradigm shift for our traditional conception of the frame. Apart from a direct concentration on the actual scene, the specified performed intention is negated. Laurence Fiston's *Panel Type Sphere* (2009) shown in Figure 31: The Omniscient Frame represented through Finston's *Panel Type Sphere*, provides an appropriate visual representation of the outer limitations of *The Omniscient Frame*. Notice that the deployment of Finston's sphere to this renewed notion of framing still allows for the existence of the window frame that looks into the sphere facilitated by the 'panels' that make up its composition. The Finston sphere offers a perspective that looks from the outside in. There is, however, a second aspect to *The Omniscient Frame* that encompasses the view and played intention of the performer. It is situated at the centre of the sphere and projects from there outwards into the capture volume. While there remain a multiple number of frames available through the panels (looking both in and out), the tradition of the frame is challenged when all of these options remain present in the one capture of performance – the scale of which is only limited by the size and scope of the capture volume the performance takes place within.

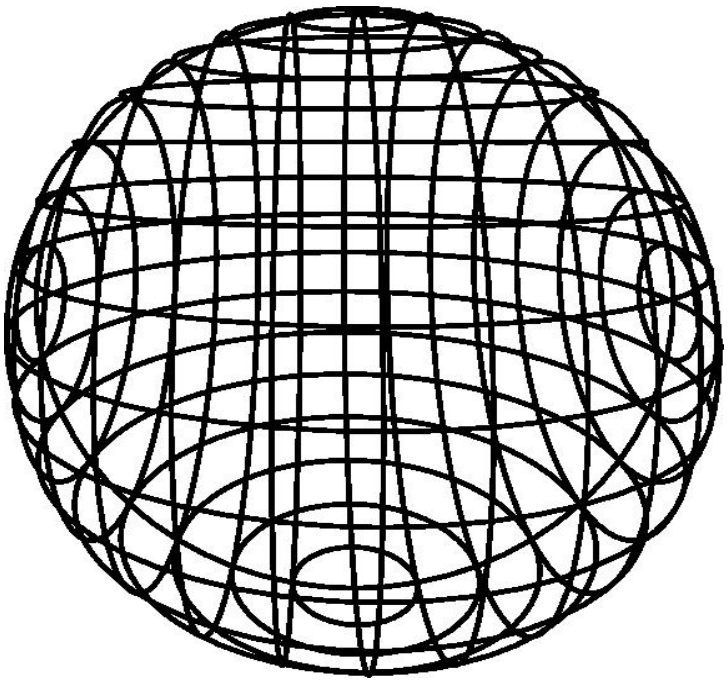

Fig 31: The Omniscient Frame represented through Finston's *Panel Type Sphere* (Image Fiston 2009)

In the history of performance the proscenium arch irreversibly changed our conception of viewing, and, just as importantly, changed our behaviour on either side of this frame. This is an often overlooked journey of 'the frame' that brings us to PeCap. While some would say it begins in the Renaissance, with the arrival of single point perspective, for this study its genealogy begins in the theatre, and has developed through film. It now presents in PeCap, where theatre, film and animation are interwoven in this new interdisciplinary form. Film borrowed initially from the window-boxed view of the stage with the 180-degree frame. It moved rapidly to a mediated frame, where not all of the body is shown, and various combinations of disclosure are revealed in mediated and edited sequences. Through framing, film attempts to show us a now from another time, a recorded now, while theatre uses the frame to pretend it is showing us a present, but one that is fictitious. The frame of film is a two dimensional planar frame that captures image. PeCap reintroduces theatricality to the frame by extending it to include depth, capturing movement (not image) and presenting to us a captured and unmediated present. This unmediated present is enabled by the performative freedom of *The Omniscient Frame* that returns the mode of performance from the

restrictions of film to the openness of the stage. Through a combination of Schlemmer's Cubical Space (1925), Bachelard's Roundness of Being (1958) and Finston's Panel Sphere (2009) the Omniscient Frame is established here as a necessary antidote to discuss the performative difference(s) and demands of PeCap.

Beyond the Geometric

Spatial exploration for the performers in the workshop cycles has been informed by the presence of a continual feedback loop of their virtual occupation of screen space. The feedback loop is the real time feed of the screen-based exploration of 3D environments, displayed on a life size screen the performer responds to as they work in the studio. By providing a traditional cinematic window of the spatial exploration and performance, the real time feedback loop challenges the notion of the global frame. It reduces the nature of performance in space to a selected point of view (POV), but this selection can be readjusted throughout the performance, depending on the needs of the performance undertaken. I use the POV to discuss how participants deal with spatial anomalies in the workshop cycles, how the various spaces of studio experience are constructed, and how the space of the motion capture suit and interactions with the boundaries of the capture volume can be informed by the virtual camera (particularly the invisible borders the performance must stay within). Through these discussions I am able to enter into the space on the other side of the screen, where the simulated environment exists and where the captured and streamed performance is recreated virtually.

In the Helsinki cycle, directing to the physical and virtual limitations of the Rose Theatre as a venue, enabled a most engaged commitment from the performers in the translation necessary to connect physical space to virtual space. This engagement was facilitated by using attributes of the physical performance space to replicate aspects of the virtual environment. The relative position of lighting fixtures in a grid, for example, were used to establish an appropriate

eyeline to perform to upper balconies in The Rose. This notion is underpinned by Lefebvre, the third spatial lens used in this study, where the physical (3D) is translated to the virtual on screen (2D). He acknowledges there is:

> an indefinite multitude of Spaces, each one piled upon, or perhaps contained within, the next: geographical, economic, demographic, sociological, ecological, political, commercial, national, continental global. Not to mention nature's (physical) space, the space of (energy) flows, and so on. (Lefebvre 1974, 8)

Similarly to Bachelard, Lefebvre asks us to consider the classification of space beyond the finality of the geometric, "that Euclidean space which philosophical thought has treated as 'absolute,' and hence a space (or representation of space) long used as a space of reference" (Lefebvre 1974, 11). In acknowledging the associated power that comes from space's 'absoluteness' when classified solely in the Euclidean, he identifies a 'simplistic' reduction from the 3-dimensional to the 2-dimensional, from the measurable real world to the flatness of the page. This concept can be translated into the act of performance captured from real space in a motion capture volume manipulated into a representation on the screen. Where the performers movement is turned to object and streamed into a software environment, Lefebvre's reduction of the Euclidean has taken place.

Nature's space is translated through an appropriation to another illusion of spatiality, where the original purpose of the space captured has been 'outlived':

> An existing space may outlive its original purpose and the raison d'etre which determines its forms, functions, and structures; it may thus in a sense become vacant, and susceptible of being diverted, reappropriated and put to a use quite different from its initial one. (Lefebvre 1974, 7)

This outlived and translated space resides at the core of this study. This developing classification of performance and the spaces they take place in the future forms part of this research's contribution to knowledge. While it is beyond the limits of this research, it may require further investigation.

Multiple Camera Exercise

The multi camera exercise contributes to a layered vision of the environment in both physical and virtual space. In this exercise a virtual camera is placed within each of the performer's marker sets. This generates the potential for the performers in the physical space to view each other physically. These perspectives can be replicated in the screen environment as a camera that replicates the potential experience of the user. In this particular act, performer becomes camera, and then 'camera operator', choosing to focus on aspects of the other's performance while contributing their own performance as a viewing perspective. When more than one camera is utilised, this generates a complete occupation of the screen environment and allows the director to begin to direct performers, not just as 'performers' but also as 'cameras'. As the occupants of the virtualised environment interact with each other in real time, their streamed perspectives activate the virtualised environment in the translation of 3D to 2D. During an exercise in Helsinki, we added to this complexity. One of the performers was placed on 'the stage' area of The Rose, while the other two were placed on the ground, acting as audience members for the performed scene in the theatre, and 'cameras' for the environment. In Figure 32: Three actors placed into the environment with two mounted cameras (Delbridge 2012), you can see the performer in the far right standing on the same level as the other two performers (the cameras), but in screen space he occupies the position on the stage. In IoP#6, Olli Haataja performs the unweeded garden soliloquy from *Hamlet* as the two other performers act as cameras for the screen. Note how Olli maintains a performative height from the actor/camera even though they all perform on the same level in the studio. This multi-camera exercise demonstrates the potential for PeCap exercises to be used in the ongoing training and preparedness of performers in our formal training institutions. It instantly connects each of the performers to the others, as well as establishing a firm link to the screen where the physical properties of their actions are used to achieve the pragmatic requirements of the virtual environment.

Fig 32: Three actors placed into the environment with two mounted cameras (Image M Delbridge 2012)

The Frame, The Counterfeit Man and The Simulated

> A whole world separates the Frame and the Counterfeit Man. One is a theatrical counterfeit, a mechanical and clock-like man; technique submits entirely to analogy and to the effect of semblance. The other is dominated by the technical principle; the machine overrides all, and with the machine equivalence comes too. The robot on the other hand as his name indicates, is a worker: the theatre is over and done, the reign of mechanical man commences. (Baudrillard 1983, 92)

Baudrillard's notion of the clock-like man dissects the apparition the performer responds to in the translation from capture volume to real time feedback loop in the PeCap space and contributes to a revised approach to the frame. The feedback loop, while acting as a mirror for the performer also acts as a window into the coded space of the virtualised. As the twenty-first century approach to generating performance embraces the connection between these principles, it expands our understanding of the field of performance capture and challenges our traditional understanding of performance, technique and the screen.

The presence of the screen is a tool for the director and performer to utilise in the act of performance, not a device to be used in the reading of performance at a later stage of the production chain by an audience. This of course inevitably occurs, but not until the captured performance data has been cleaned, adjusted, framed and manipulated for the final product. While there may be aspects of the performer becoming ‘user’ as they read their own work in the act of performing, it is the connection between the real and virtualised space that the window provides. The clock-like man inhabits the machine, revealing the virtual to the performer in the act of performance.

The ‘apparition’ is challenged when the screen is deployed as mirror, and supported when deployed as window. In this context, ‘apparition’ is applied to that which can be seen, but whose meaning is not necessarily clear. It is in this mode that the work of the performer in physical space similarly shifts from simulacra to simulation; a simulacra in the mirror, a simulation through the window (Baudrillard 1996). Through a connection of self to self (the physical to the screen), a focused discussion on framing in virtualised space occurs. Practical exercises are used to connect the performer to the screen, and through this, connects the performer to an apparition of self. This study asserts the privilege of the feedback loop as a new, and vital, infrastructural innovation the project makes to this emergent field. When we subject performance to contemporaneity, an existence that is simultaneous, an understanding of this simultaneity can only be realised through the act of live feedback and *The Omniscient Frame*. A performer can occupy circular space and inhabit a simultaneous screen that is circular as well (this apparition of circularity is a simulacra as the screen is flat and not circular). And it can occupy coded space, the landscape of the reproduced copy of the potentially once existent; in this case, the reimagined screen-based model of the Rose Theatre.

For Baudrillard, the first stage simulacra is the image or copy that is faithful; the second stage simulacra is unfaithful, hinting at a truth or reality; the third stage

pretends to be a reality (or copy), but there is no original for this copy; the fourth stage simulacra is a pure simulation, with no relationship to reality whatsoever. Working in PeCap we slip through all four stages of Baudrillard's stages of the simulacra. The simulation of the performance on the stage – simulated, in that it is an imitation of an occupation of an early modern theatre (in the case of this workshop), but indeed all of this capture work is destined for the simulated imitation. The performance space as a gridded floor with 3D objects is even more a simulacra than the actor. All performers occupy a variation of simulacra (whether this be first, second, third or fourth stage).

In the workshop cycles, the final explorations performed in the Rose Theatre, (a theatre not demanding of authentic response), descended into anxious debate around perceived authenticity. The SAA driven in the environment was a simulacra of the actor – a copy based on an absent original, part Shakespearean actor, part clone, part working digitised spine, anything but real. By exploring aspects of Baudrillard's double and the simulated after Craig's *Über-Marionette*, the misconception that the performer driving the avatar can seem authentic within the screen is revealed.

> Of all the prostheses that mark the history of the body, the double is doubtless the oldest. But the double is precisely not a prosthesis: it is an imaginary figure, which, just like the soul, shadows the mirror image, haunts the subject like his other, which makes it so that the subject is simultaneously itself and never resembles itself again, which haunts the subject like a subtle and always averted death. (Baudrillard 1983, 95)

In order to address and negate this tension, an exercise was developed called Hand Frame'. Hand Frame builds on the single virtual camera exercise, and introduces the performer's hands as a framing mechanism to connect the physical to the virtualised performance environment. A virtual camera is placed on the performer's marker set around the sternum. When the performer extends their (physical) arms, their other (virtual) arms come into frame on the screen in a similar way. The hands are then used as framing devices to facilitate movement

through the environment. This action encourages a sense of connection between physical and screen space, allowing the performer to frame their performance in an alternate mode to the screen. When the exercise was conducted on The Rose Theatre stage, it enabled a substantial connection to audience spaces of the venue and a smoother transition for the performer to connect with each of the three tiers, the groundling area on the floor, and the Lord's box behind. Hand frame provides a bridge from stage to screen, occupying the liminal space (or threshold) between physical and virtual. The spatial connection of the two bodies, facilitated through this bridge, provides the necessary route for the performer to move into the unique performative environment of performance capture. To view this exercise in more detail see IoP#7, where Jaako Ohtonen performs a soliloquy from *Macbeth* in the second workshop cycle and continuously frames the character's POV with the virtual hands of the SAA. This simple act of maintaining his virtual hands in the frame establishes a meaningful connection between himself and the world of the screen.

Fig 33: Jaako Ohtonen performs Hand Frame, Workshop #2 Finland (image M Delbridge 2012)

Conclusion

The practices we deploy in theatres and film studios occupy both physical and mental spaces in our understanding of contemporary performance. The motion captured space, while borrowing from spatial traditions, also occupies it's own version of the physical, the mental and the virtual. The spatial context provided by Schlemmer, Bachelard, Lefebvre and Baudrilla, provides a basis for the identification of the spatial dilemma at the centre of performance that occupies both physical and virtual space. Further nuance is added to the dissection of this dilemma in the next chapter, Tool Use and Time, where the essential function of movement in the exploration of PeCap is privileged and the operation of tools that record movement in space are analysed.

Chapter 4
Tool Use and Time

There have been two capital events in the course of human history: the making of tools (with which work was born); the making of art objects (with which play began)

(Bataille 1955, 27)

Tool Use and Time

One of the most revealing moments in the practical workshop series occurred in workshop three, with Peggy Shaw. Approximately 12 months earlier, Shaw suffered a stroke at her home in New York. While this may not at first seem significant to this study, it provides a contextual lens for this chapter's discussion on tool use and time. Shaw revealed, as she was driving the neutral avatar (the actor in MotionBuilder), that this was the first time she ever truly noticed the way she moved. Peggy Shaw is a performance artist and activist who spends most of her life dressed as a man. The feedback loop receiving a stream from the concrete present of the performance space provided the first true picture of her – an instant representation that was beyond any constructed gender identity. More importantly, Shaw revealed that this was the most she had moved since her stroke 12 months earlier. The session took place over 8 hours in the Deakin Motion.Lab and Shaw didn't stop interacting with the screen the entire time. Her noticeable increase in movement was simply because she realised that if she didn't move, the avatar in the real time feedback loop didn't move either. She wanted the actor to keep moving, and felt obliged to keep the avatar moving as well. Shaw formed a natural relationship with the tools of the environment, instantly connecting to the reproduced other on the screen.

Fig 34: Peggy Shaw in Workshop Three (Image M Delbridge 2012

Shaw's rigorous engagement with this process illustrates the compelling and complex lines that run between the actor and the avatar when performance is captured with the tools of MoCap. This chapter examines these complex lines, and frames them within a network of relationships that are vital to PeCap. These relationships centre on the operator and time, performing to machines and the digital in the *techné* of performance. To undertake this examination, I draw on Walter Benjamin (1936), Luigi Pirandello (1926), Gabriella Giannachi (2004) and Laura Mulvey (2006) to provide a theoretical foundation for the tool-centred practice of performing and operating MoCap systems. This tooled perspective is central to the practice of performing in a MoCap studio and furthers the twenty-first century approach to performance capture at the heart of this study.

Pirandello's *Shoot! (Si Gara!*)*, The Notebooks of Serafino Gubbio, Cinematograph Operator* (1926) offers a useful, arguably profound, insight into the machinic (or tooled) intervention between director, operator, actor, device and performance. It provides a historical perspective that expands our understandings of the field of performance capture and makes a significant contribution to the tool use and time domain. Better known as a playwright of works such as *Sei personaggi in cerca d'autore* (*Six Characters in Search of An Author* 1921) and *Vestire gli ignudi* (*To Clothe the Naked* 1923), Pirandello's *Shoot! (Si Gara!)* (1926) addresses a key issue that emerged with the advent of film: the place, space and function of the performer in the captured environment.[20] The dilemma Pirandello describes is the same one we face in the MoCap studio, as vital now as when it was written nearly a century ago.

Walter Benjamin's essay *The Work of Art in the Age of Mechanical Reproduction* (1936), unearthed *Si Gara!.* Referring to Pirandello, Benjamin argues that it is the "dramatist who instinctively identifies that distinguishing characteristic of film as causing a crisis we see befalling the theatre" (19). The crisis referred to here

[20] I stumbled upon *Shoot! (Si Gara!)(1926)* through Benjamin's *The Work of Art in the Age of Mechanical Reproduction* (1936) and while I was confident that Benjamin would be important contextually for this study I could not have imagined how important *Shoot! (Si Gara!)* would become.

(particularly in the early twentieth century), is not just the economic impact on the theatre industry by the rising popularity of film. Benjamin raises a concern with the ongoing affect of the work, image and aura of performance captured. This concern is philosophically connected with the space, place and function of the actors' relationship with themselves, with an audience, and the inevitable forced relationship with the mechanical and chemical tools of film where "the camera is substituted for the public and the aura that envelops the actor vanishes" (1936 in *Illuminations* 1969, 229). The dilemma around the capture and reproduction of the aura of performance remains similarly unresolved in PeCap, and I contend that this dilemma is amplified with the limitless reproducibility of the digital.

The Aura of the Performed Object

Benjamin refers to the capture and destruction of the aura of a subject as the afforded, distinct impression of character and aspect. This is understood clearest when set against the potential personal experience of nature:

> Lying back on a summer's afternoon gazing at a mountain range on the horizon or watching a branch as it casts its shadow over our reclining limbs we speak of breathing in the aura of those mountains or that branch. (Benjamin 1936, 9)[21]

The aura is experienced and perceived in a singular moment. The time of interaction is eliminated, or fades, when superseded by mechanical reproduction. Regardless of how exact the reproduction of the original may be, the initial point of presence will always be lost in the reproduced. It is the interaction between subject and object, that is, the personal mountain/branch experience that provides our connection to aura. For Benjamin aura is related to presence "it's presence in time and space, it's unique existence at the place where it happens to be" (1936 in *Illuminations* 1969, 214). This destruction of experience (or

[21] There are many approaches that have been applied to Benjamin's use of the term aura and contemporary performance see Lise Patt (2001), Graeme Gilloch (2002) and Cormac Power (2008). In this study however I refer solely to the primary source The Work of Art in the Age of Mechanical Reproduction (1936).

fading) is comparable to the loss of presence the performer (and audience) encounter in the reproduction and capture of performance from MoCap studio to multiplied screen. For Benjamin a new artefact emerges. One that becomes exhibition as opposed to sacred object:

> With the close-up, space expands; with slow motion, movement is extended. The enlargement of a snapshot does not simply render more precise what in any case was visible though unclear: it reveals entirely new structural formations of the subject.
> (Benjamin 1936 in *Illuminations* 1968, 236)

The impact of the close up is an important one to consider in terms of performance aura and the reduction to exhibition. Relative 'distance' is an essential aspect of this experience as the camera reduces distance in the live experience to a close up in the mediated. It is important to remember that "Distance is the opposite of closeness" and for Benjamin this collapsing of space (and time) is an essential aspect of "the contemporary decay of aura" manipulated to the 'profane' (1936 in *Illuminations* 1969, 223). The impact of this for PeCap is concerned with what is actually captured with contemporary MoCap tools and what elements of the aura of performance are lost (or decayed) when the mechanical, chemical or digitally mediated intervenes. As such, the term aura is applied in this study to explore how notions of performance are now manipulated, reproduced and subsequently altered in extremes. Here, I refer to those beyond the mechanical and chemical reproduction and the intervention identified by Benjamin:

> Uniqueness and duration are as tightly intertwined in the latter as are transience and reiterability in the former. Stripping the object of it's sheath, shattering the aura, bear witness to a kind of perception where a sense of similarity in the world is so highly developed that through reproduction, it even mines similarity from what only happens once.
> (Benjamin 1936, 10)

The question concerning the primacy of an individual's voice and image has been vigorously interrogated in the academy over the last century, and is now

accepted and appropriately protected. However, questions around the acknowledgement and ownership of a performer's movement, captured in *The Omniscient Frame* have, until this study, not undergone substantial academic scrutiny.

The Empty Top Hat: *performance as test*

A contributing factor to consider is what Walter Benjamin refers to as Pirandello's *performance as test*:

> One of the first people to sense this transformation of the actor as a result of *performance as test* was Pirandello…The fact remains, the acting is done through a piece of equipment, or, in the case of the sound film, two pieces of equipment. (Benjamin, authors own emphasis, 1936,18)

Benjamin discusses the potential consequences of the 'equipment' intermediary on the artistic performance of the screen actor. The device, in this case a film camera or projector, mediates the performance of the actor, and is not obliged to respect that performance. Guided by the operator, the camera comments on the performance continuously. The outcome of this commentary, which is then reassembled in the editing process, is the final film. It includes a series of movements that come directly from the camera, and with it, the operator. Through this application, the actor's performance is regarded as a series of optical tests (Benjamin 1936).

In the subsequent replay and reproduction enabled by the digital MoCap system, the performer, and the capture device's performances are viewed and reproduced in the screen-based illusion of the 3D virtual environment. At the same time, their performances are impacted on, and are affected by, their illusory connection to the intermediary. This connection exists as a mediated event between the capture device and the actor's aura, where the true connection is established with device in the first instance and with the performer secondarily.

This notion of the *performance as test* places the contribution of the performer (including their transformation through PeCap) outside of Benjamin's description of 'the divine'. For Benjamin, the concept of the divine in performance is that which is revealed only after the ephemeral act of performance has passed. The performance to the device diminishes the act of performing to that of function, and increases the notion of fading, "pumping the aura out of reality like water out of a sinking ship" (1936 in *One Way Street* 2009, 250). Benjamin assumes that the introduction of the second device (related to the additional recording of sound) adds nothing substantially new to the dilemma. When taken into account that this increases the extra layer of performance able to be reproduced, it is (as Pirandello asserts) a substantial addition to the record.[22]

While aura positively refers to the divine, unnamable and mysterious, for this discussion the term is applied with acknowledgement to the root of authenticity and the ability for the authentic to be stripped away once traditional (mechanical) reproduction commences. This understanding comes directly from a formal application of Benjamin's use of the term where "that which withers in the age of mechanical reproduction is the aura of the work of art" (1936 in *Illuminations* 1969, 221). This application and furthering of the term suggests that PeCap (and its inherent reproducibility) *preserves* aura through a digital mode of production (without degradation) that captures the movement of performance using a MoCap system and prevents the 'withering' of aura in mechanical reproduction. This is the major distinction from traditional film and the benefit of capturing and performing in an Omniscient Frame.

It is important to place both Pirandello and Benjamin into a broader historical landscape (both geographically and socially) to gain a clearer understanding of the significance of their particular identification of this issue. For Pirandello, in 1920s Italy (living and working in Rome in 1922), the most important external influence has to be located with the emergent rise to political power of the Partito

[22] The recording of audio was less prone to operator influence for Pirandello, as the device was automated and not reliant on the manual turning of the handle like the cinematograph.

Nazionale Fascista (PNF) and the electoral success of Benito Mussolini as Prime Minister. The year, 1922, coincides with Pirandello's cessation of his formal academic career at the Real Istituto di Magistere Femminile, where he was a professor of aesthetics and stylistics for 25 years. It is not known officially why Pirandello ended his academic career, but Mussolini's support for the establishment of Pirandello's National Art Theatre of Rome (Teatro d'Arte di Roma) in 1923 and Pirandello's membership in the Fascist Party that same year may be connected. Here existed in Italy the formal beginnings of a broad rejection of state-driven individualism. Now commonly understood as a key component in generalised definitions of fascism, it may have been a contributing factor in the identification of the actor's dilemma, for Pirandello.

Pirandello was initially a firm believer in, and a vocal supporter of, Mussolini, until, quite famously, 5 years after the founding of Teatro d'Arte di Roma, he referred to the dictator as "An empty top hat, unable to stand up by itself".[23] The dilemma we see identified by Pirandello as associated with the loss of individual aura for the performer (and performance) when captured, may allude to his personal feelings on much larger issues in Italy at the time. The seed of some of the associated loss can be found in his earlier works, *Six Characters in Search of an Author* (1921) and *Art and Consciousness* (1893).

In considering *The Work of Art in the Age of Mechanical Reproduction* (1936), where the link between Pirandello's *Shoot! (Si Gara!)* (1926) and Benjamin is established, it is possible to trace the influence of questions around individual identity loss and preservation. For Benjamin, living and writing on the run in 1930s Europe, the influence of impending fascist dominance and personal persecution is much more prevalent and obvious in his work. Benjamin was an

[23] The original source of this quote is hard to pinpoint but is attributed to Pirandello in many 2nd and 3rd party sources see: http://atireugram.blogspot.com/2008/06/luigi-pirandello-1867-1936.html, http://www.kirjasto.sci.fi/pirandel.htm and http://amedeoamendola.xanga.com/569373292/68-glintellettuali-moderni-dellausonia-b/

active member of the Frankfurt School and the Institute for Social Theory in the founding days of their inception and found a lasting connection with the work of Pirandello in his own theoretical search for both the preservation and identification of the individual.

As the role and import of the operator begins to fill out, it is essential to draw the impact of time and the machine into the discussion. This is especially the case when we acknowledge that people must operate machines that capture and record performance. It is this humanness that further contributes to our understanding of PeCap and provides a contextual link between filmic history and the practice central to this study.

The Operator and Time

> I at once assume, with it in my hand, my mask of impassivity. Or rather I cease to exist. It walks now upon my legs. From head to foot I belong to it. I form part of its equipment. My head is here inside the machine. (Pirandello 1926, 86)

Pirandello's cinematograph operator, Serafino Gubbio, discusses the film camera as an integral extension of himself as the operator, and as an external device needing to be fed; a machine/operator interface with a constant hunger, "I prepare my machine for its meal" (Pirandello 1926, 86). These notions of feeding and 'consumption' are central to what is lost from the live in the act of performance where the machinic interface consumes time.

When the machine takes only what it needs from the performance, what it has been machinically focused to see and record, the operator is implicit in this taking. The operator remains manually connected to what the machine can see: "my eyes and ears, from force of habit, are beginning to see and hear everything in the guise of this rapid, quivering, ticking mechanical reproduction" (Pirandello 1926, 10). The machine that takes, this object that draws, frames and determines

focus, is another integral component of the concerns of Pirandello and Benjamin. Reproduction and mediation is central to the dilemma of the place, space and function of performance in the captured habitat. The inherent lack of respect afforded to the performer by the apparatus is obvious and the central character in the capture scenario, the actor, is challenged if we consider that all parts of the environment have equal weight and/or significance. The device could be viewed as the central component of the experience for the audience. The relationship of the viewer with the performance captured is in many ways comparable to a functionary role that exists only to showcase the work of the device.

As part of the discussion on satiating the machine, Pirandello links the relationship between the concept of hunger and feeding to that of the taking of life (and time) where “all the life that the machines have devoured with the voracity of animals gnawed by a tapeworm is turned out here…the life swallowed by the machines is there, in those tapeworms, I mean in the films, now coiled on their reels” (Pirandello 1926, 84-5). Through this idea of ‘life storage’, the worms “coiled on their reels” (ibid), he alludes to the reproduction dilemma, the cutting together of one life passed (but captured in its original) to create a new one. This subsequent rebirth is facilitated through the intervention of other machinic and chemical intermediaries: the processed, edited, graded and projected film. The projector plays a similar role, providing its own clicking and whirring commentary on the experience. It does so while it maintains its own operator.

As the presentational device occupies the exhibitor space, as opposed to the active intervention of the camera, it becomes more re-animator than monster. The projector as intermediary supplies the reproduced with its invigorated movement and ends the suspension of time taken from performance. As Pirandello asserts, “We have to fix this life, which has ceased to be life, so that another machine may restore to it the movement here suspended in a series of instantaneous sections” (1926, 85).

The Operator and the Machine

A key factor in determining the link between what is 'lost from the live' and what is found can be attributed to the role of the operator. For Pirandello, the operator Serafino Gubbio (nicknamed Shoot), switches roles between both machinic component and external observer, and Shoot (the character) is deployed by Pirandello in different guises to explore both of these concepts. The infrastructure associated with early filmic capture assumes a function from the individual, but does not allow, or has no room to cater for, the canniness of the operator. This individual canniness is particular to the operator of the device, a key, and yet, in many ways, unrecognised, component of the interface:

> I, my dear sir, do not always turn the handle at the same speed, but faster or slower as may be required. I have no doubt, however, that in time, sir, they will succeed in eliminating me. The machine, this machine to, like all other machines will go by itself. But what mankind will do then, after all the machines have been taught to go by themselves, that my dear sir, still remains to be seen.
> (Pirandello 1926, 8)

Pirandello's positioning of the role of early camera operation poignantly highlights the tension between the human/machine interface. The manual handle provides a layer of intervention between performer, audience, and the machinic vision tool. The gap between these layers offers a glimpse of the meaningful preservation of the aura of the performance captured. However, the aura preserved is as much that of the operator as it is of the actor. While the operator in early film may proclaim the impassive, Pirandello's pinpointing of the tension between these two modes of capture underlines the value his text has in the theoretical underpinning of contemporary PeCap.

There is an intrinsic element of responsibility here, which is described by Pirandello's operator as he controls the capture rate of the camera by following the emotional and physical pace of the actors. The tension between this physical human response and the recognised need for the impassivity of the camera

operator to enable a mode of capture consigns the role of the camera to that of a documentary device that enables a 'footprint' recording. This notion of the footprint, as described by Laura Mulvey in *Death at 24 x a Second* (2006), resides outside of the dramatic paradigm that Pirandello interrogates. For Mulvey, the footprint is an unbiased document, as much a record of a particular period in time than anything else. The footprint is the record of events undertaken completely and impassively. The operator in *Shoot! (Si Gara!)* (1926) is anything but impassive. The whole establishment of the physical space to be shot; the amount of time to be shot; the frame of vision; are all established by the human intervention with the machine and the establishment of what the device enables. As Pirandello notes:

> I am an operator. But, as a matter of fact, being an operator, in the world in which I live and upon which I live, does not in the least mean operating. I operate nothing. This is what I do. I set up my machine on its knock-kneed tripod. One or more stagehands, following my directions, mark out on the carpet or on the stage with a long wand and a blue pencil the limits within which the actors have to move to keep the picture in focus. This is called *marking out the ground.* The others mark it out, not I: I do nothing more than apply my eyes to the machine so that I can indicate how far it will manage to *take.*
> (Pirandello 1926, 6)

This description of the operator's relationship to the machine is crucial to the taking (and capturing or feeding,) of the aura of performance. The act of capture becomes a human intervention. Pirandello's operator alludes to a sense that he remains impassive throughout the capture construct, but the presence of impassivity, especially in the establishment of the 'frame', is not always there.

In MoCap, the performer's place and function shifts from performer to impassive component of the environment. Performance undertaken within the parameters of *The Omniscient Frame* at capture rates in the hundredths of a second, allows for a performance approach that can potentially address these dilemmas identified by Pirandello and Benjamin. The ability to accurately capture an

individual's movement, and the MoCap template's capacity to inform and influence the interface, lays the ground for questions concerning the place and function of performance and technical operation in mediated environments. Understanding the digital in performance is thus essential to framing this discussion of tool use within the practice of performance capture. It contributes to the building of a twenty first century approach to PeCap, and incorporates a discreet understanding of the concept of manipulated time.

The Digit in the Digital

The term digital begins with a root related to the finger (or of the finger) *digitalis*, (connecting to the pushing of the button) and the subsequent notion of the digit as "a whole number less than ten" (OED online, accessed 18th March 2013). Accepted contemporary definitions speak closely to the "signals, information, or data: represented by a series of discrete values (commonly the numbers 0 and 1), typically for electronic storage or processing" (ibid). In this study, the definition of the digital used must also incorporate the designation of a "virtual, computer-mediated counterpart of an object that exists in the physical world" (ibid). The real time display of transformed data reconstructed as a representation of images (and other artefacts) in screen space is a central aspect of this. These notions are expanded through an examination of what is known as 'digital performance'. Charlie Gere in *Digital Culture* (2002), Johannes Birringer in *Performance, Technology and Science* (2008), and Steve Dixon in *Digital Performance* (2007), offer pragmatic definitions of the digital in performance that can assist the foundational nature of this study.

Gere suggests the digital:

> has come to mean far more than simply either discrete data or the machines that use such data, to speak of the digital is to call up, metonymically, the whole panoply of virtual simulacra, instantaneous communication, ubiquitous media and global connectivity that constitutes much of our contemporary experience.
> (Gere 2002, 11-12)

For Gere, the term is central to any formal understanding of our contemporary experience, surrounded as we are with a vast array of digital responses in most aspects of our lives. In our understanding of performance, the change that has arrived is as much concerned with the significance of what now constitutes a 'stage', Birringer asserts that:

> The arrival of coding, digital medium, and mobile (or multiple) cameras and sensors in the performance space changes the stage and the screen spaces, as we are no longer tied to the traditional role of motion pictures and the machines of motion created in the nineteenth century to produce the illusion of motion. The digital is not the cinematographic; it produces a machinic vision, an algorithmic writing of data. Its new attributes include programmability, interactivity, and virtuality.
> (Birringer 2008, 8)

For Birringer, this interactive programmability generates a new form of illusory motion, and when we represent motion on the screen (captured on a stage) we are doing nothing more than this. The recreation of a version of what was captured (accurate though it may be) through the digital, also allows us to break information into such a multitude of small parts that enable any form of reconstruction to be anything but original (or accurate). The digital interpretation of the optical information captured provides a true 'machinic vision', playing a key role in the construction of what becomes the input data for characterised avatars in virtual space which are themselves machinically influenced or tooled. This allocation of the machinic interpretation is key to a subsequent definition of what could be described as digital performance. In his groundbreaking work *Digital Performance* (2007), Steve Dixon defines digital performance as:

> all performance works where computer technologies play a *key* role rather than a subsidiary one in content, techniques, aesthetics, or delivery forms. This includes live theatre, dance, and performance art that incorporate the digitally created or manipulated.
> (Dixon 2007, 3)

Gabriella Giannachi's *Virtual Theatres: An Introduction* (2004) discusses how performance in screen space is not necessarily just viewed by the audience, but is also manipulated in the act of viewing. In the act of generating the virtualised theatre (and in this project we populate a virtualised model of The Rose with performance, framed as a simulacra in the previous chapter), it is not simply the actor that is directed with performance but the virtualised venue too. The venue becomes actor, the environment becomes performer and the performance (of the operator, actor, animator and director), once virtualised, becomes an aspect of the overall venue's performance for the user (or viewer). For Giannachi, "the performer of virtual theatre is inside the work of art, not only metaphorically, but ontologically" forever connected and bound to the screen space (Giannachi 2004, 7). The most important aspect of virtual theatre is the ongoing connection between the real and the virtual environment. In the strictest sense, this connection is framed (in formal definitions of virtuality) around the viewer in real space and the presented performance (or environment) in the virtual. In the generation of performance destined for the virtual this connection is still present when framed slightly differently. When the performer is placed in the position of user, connecting between the real and the virtual, they contribute to the construction of this virtuality. The "virtual theatre constructs itself through the interaction between the viewer and the work of art which allows the viewer to be present in both the real and the virtual environment. This interaction is perhaps the most important characteristic of virtual theatre" (Giannachi 2004,11). In this research the interactions generated between physical, coded, and screen space adhere to this understanding of the virtual.

Techné in Performance

The relationship between tools, their use and time, and their influence on the development of performance capture is grounded in a contemporary understanding of *techné* and supported by a theoretical discourse from John Dewey (1910), Larry Hickman (1992) and Charlie Gere (2006). In this instance the tools referred to are in the Heideggerian sense 'those which are to hand': the

motion capture system and software workflow. The applied use of digital tools and the approach developed to capture performance, resides within the notion of work and this to-handedness, particularly where, “Work anticipates, presupposes the object that does not yet really exist, which is presently being made, and which is, simply the reason the work is being done” (Bataille 1955, 28). The work the tool anticipates, and then brings into existence, is performance captured in a physical volume for a screen-based 3D environment, like the rock and hammer Bataille refers to in the chapter’s opening quote.

When the notion of *techné* was established in ancient Greece it offered much more than a means of acknowledging a learned skill or “kind of professional competence” (Hickman 1992, 17). It was concerned with bringing order to places of chance “bringing to completion natural events and objects for the sake of human purpose” (ibid). The application of *techné* “occupied a sort of intermediate space” between the experience gained through practice and the application of theoretical discourse (ibid). This traditional understanding of *techné* resides at the heart of the technological approach to operating, directing and performing for PeCap, an aspect of the identified gap in knowledge this research fills. It occupies the liminal space, the threshold bridging traditional notions of performance and performance making with the population of the screen (in all its sites of understanding). Technology theorists (such as Marx 1863, McLuhan 1961, Dewey 1910/1938, Needham 1954 and Gassett 1930) note that any study of technology involves a “remote past, an immediate past and an immediate future” (Hickman 1992, 81). Our immediate past and future are intimately connected to notions of performance in screen space. The approach to performance capture this project proposes facilitates generation of content for the screen into the future. The notion of technical performance is not new. We apply a technological approach to performance in both the theatre and film studio as a matter of course. This study proposes that there is an opportunity to adapt our current understandings of the existing technological approach to performance in both film and theatre to performance capture. Any approach to performance is a

form of tool use, responding to the challenges and demands of a contemporary environment.

This relationship of technicity and tool use to knowledge can be anchored through a reading of Larry Hickman in his discussion of the work of 1930s educational pragmatist John Dewey in *Philosophical Tools for Technological Culture – Putting Pragmatism to Work* (2001). Hickman paraphrases Dewey's philosophy as follows:

> Knowing is also relative in the sense that it involves connections to other knowers. Knowing is sharpened and extended by taking the stances or viewpoints of others within a community of inquiry, that is, by considering a problem from as many differing perspectives as possible.
> (Hickman 2001, 48)

The connection to other knowers, specifically in relation to the motion captured environment, can be re-appropriated to include all users of the system. This point is important when we consider the unique ecology of a motion capture studio. When animators are placed alongside actors and technical operators alongside fight scene directors (who themselves may have never directed formally trained actors before), this connective knowing needs to be established within the habitat, virtual and otherwise. The technicity of the environment is the common community, and as motion capture remains a relatively new form, there exists an absence of common knowing that participants are a collective part of.

The tools used to enable the capture of movement have developed through an applied understanding of our inherited theatrical and filmic histories and are driven by technological knowing. In *Experience and Education* (1938) Dewey tells us:

> we live at the time we live and not some other time, and only by extracting at each present time the full meaning of each present experience are we prepared for doing the same thing in the future. This is the only preparation which in the long run amounts to anything.
> (Dewey 1938, 29-30)

What Dewey sees as instrumentalism, mixing tools with media to generate technological cognisance, is a response to the circumstances presented to us. The transformation of our understanding of the place of tool use and time is bound to the digital and, through it, the virtual. The dialogue around performance and time remains fundamentally concerned with the application and use of tools. An exploration of the early twentieth century clash between the cinema and the stage highlights the place and function of captured performance mediated through the time/tool paradigm (Mulvey 2006, Pirandello 1926). How we frame the creation of performance is fundamentally concerned with the application, use and capture of time. It must negotiate the impact time-signatured or time-based capture of performance has had – and will continue to have – on the function of operators, directors, actors and animators in performance capture.

In *Death 24x a Second* (2006) Mulvey positions traditional film as the physical marking of an actual moment in time, an inscription based on chemical and organic processes and regards the digital filmic process as closer to pre-filmic animation. Mulvey asserts an implicit association with the concept of the frame, the frozen still image (once only a territory accessible to the projection room), and the concept of stealing time.

This is what the digital allows.

This notion of the pause, or the frame, is related to the theft of aura. It is the ability to be able to capture a frame that provides the connection from film to motion capture, for the frame is ultimately tied to celluloid (the chemical capture of image and performance) and has contributed to current abstractions of time. A more accurate way of describing motion capture and current digitally mediated capture scenarios is related to a deployment of the impassive, mentioned earlier. This notion of the impassive provides a means of describing the allowance of the interface to create an open space (within set and widely defined parameters) that is able to capture unframed motion within a set environment, that in its raw state

remains unbiased. Motion capture employs a version of Mulvey's footprint (2006), in that the deployment of *The Omniscient Frame* remains, in the initial 360-degree capture, completely open and absolutely precise.

Time is connected to the frame and this concept of captured time relates directly to movement. As the performer moves within the environment he/she occupies, a time signature is directly linked to the capture of their performance in frames. Through this exploration, a tension emerges between the traditional frame, a still image, once the territory of the projection room, and the concept of 'stealing' time (the spatial dilemma of the frame and its connection to theatre and film). Time manipulation, with its potential to impact on the viewer's ability to pause digital content and capture the representation of a frame (linking this to a contribution to current abstractions and expectations of time) suggests that film, and film theory in particular, can make a significant contribution to foundational discussions on the role of performance capture in contemporary practice. This is made apparent when interrogated through the time optic, as discussed by Gere (2006) and Mulvey (2006).

This particular construction of time, allows a significant bridge between the real and virtualised performance space for PeCap. The real time feedback loop is vital in the construction of performance and in the representative translation of the physical to virtualised time. The spatial implications of the feedback loop, and the connection it provides between spaces, relates to the instant response provided from the loop as it acts as both mirror and window. The interaction between the two environments, facilitated by this real time connection, is key to the performer's ability to respond to the competing demands of physical and virtualised performance environments.

Conclusion

A key factor in the use of motion capture in commercial production (and the developing application of performance capture) is connected to a broad understanding of the primary function of tool use; that tools enable us to use time more efficiently. Motion capture enables animation for gaming, advertising and commercial film production to be completed in an efficient and timely manner. The most basic of capture scenarios, a walking cycle, may take an animator using traditional techniques (that include the 12 stages of animation discussed earlier) several hours to complete. Using motion capture, however, a walking cycle can be completed in a fraction of the time. The economic imperatives related to the cost effective creation of commercial entertainment products, reside at the core of the dilemma this project seeks to answer.[24]

The relationship discussed between movement, early capture dilemmas and visual navigation of virtual environments is key to establishing a foundation for performance capture. The establishment of these connections allows the operator, performer and director to manipulate the digitally mediated navigable space as an environment that facilitates occupation and habitation. In the next and final chapter, Environmental Navigation, a practical approach to generating PeCap is finalised through the addition of the environmental discourse of visual perception.

[24] While it may seem strange to acknowledge that this is a key factor and then not contribute to its resolution, an examination of the labor strategies deployed in creative production is beyond the scope of this study but provides opportunities for research into the future.

Chapter 5
Environmental Navigation

The same stone may function as a shelter for the crab that hides beneath it, as an anvil for the thrush that uses it to break open snail shells and as a missile for an angry human to hurl at an adversary.
(Uexkull 1982, 29)

Environmental Navigation

As an ecology, the motion capture environment has evolved over time in response to our changing approach to generating performance, both live and for reproduction. Focus in this chapter is on the physical and environmental evolution of performance spaces and the necessary habitation of these spaces that have influenced their development. As the capture of motion is represented and replayed as a visual display in screen space, it is fitting that this part of the investigation, the navigation and perception of environment, is primarily undertaken through a visual lens.

The work of ecological psychologist James J Gibson, and his pursuit of a redefinition of the conceptual frame to determine how visual perception is formed, became central to the development of a theoretical framework for this study. It is, therefore, important to define the environment in ecological terms; that is, the place where the cognate live and occupy afforded aspects of space (Gibson 1979). The notion of 'affordance', the concept of what the familiar object in an environment affords, is a key element of Gibsonian theory. It is applicable to the initial navigation for working within a geographically, socially or professionally unfamiliar, but recognisably afforded habitat, and is key to locating performance in the unfamiliar MoCap environment.[25] The term is variously applied from discipline to discipline (from robotics to dance) and is most useful when used as a source of inspiration for further extrapolation. In this study it is applied in the sense that values and meanings of objects can be directly perceived through a set of visual triggers (memories etc).

[25] The term affordance can be understood variously between disciplines and different quotes from Gibson's writings are often used to support different views on the concept. For example it is a term often used in robotics, see Turvey (1992), MacDorman (2000) and Stoffregen (2003). For Gibson learning is not a part of affordance – perception is the key to applying meaning to an object in an environment, not its applied or subsequent use which necessitates a step beyond Gibson's own application of the term (see Sahin et all 2007).

Three key points are established here. The first is that motion capture is bound to a particular technologised infrastructure that has naturally evolved from the infrastructures of our theatrical and filmic history (this has been addressed in some detail at various stages in the thesis); the second highlights that a primary aspect of any initiation to a new space is environmental; and the third, that modes of navigation for performance in screen space, directly translated from physical space, have been under-theorised before now, and are best understood through practical exercises undertaken in motion capture studios.

The following section examines the practical process of introducing performers to the motion capture studio and establishes three stages of initiation to the performance capture process that have been devised as part of the study. These stages are: navigating the initial capture space and the actor template; navigating the previsualisation software and neutral actor and; navigating the characterised avatar and modelled venue. This tripart workflow forms the first of three ternaries of understanding that have been developed as part of the foundation for PeCap. Presented as three visual models, they have emerged from practice and are presented as a key aspect of the environmental domain of understanding. As such, they make a significant contribution to the developing approach to PeCap for the twenty-first century.

Stages of Initiation

Navigating the initial capture space and the actor template

The first of the navigation exercises in the workshop cycles focused on the initial capture space, including the physical boundaries of the Deakin Motion.Lab and the Studio at Aalto. This navigation forms the first stage of the workflow for the performer and includes the templating/object workspace supplied by the cameras central to the optical MoCap system. The templated object is the fundamental stage of capture and initiation for the actor. Without a rigid template the subsequent stages of the performance pipeline will not be robust and can cause the subsequent layers of neutral actor and character to collapse. This research

suggests that performers benefit from the three stages of the workflow sequentially. The first stage of the pipeline, controlled by the Motion Analysis capture software Cortex, generates the most abstracted version of visual feedback for the actor (see Figure 35: Screenshot from Cortex, Delbridge 2012).

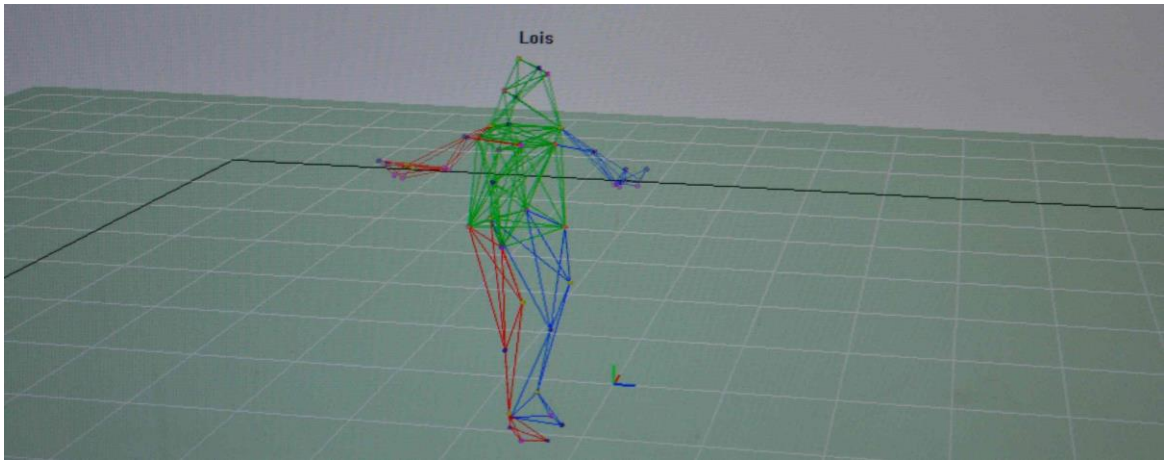

Fig 35: Screenshot from Cortex (Image M Delbridge 2012)

The suit is the actor's first connection between operator and performance. A vital component of this phase of navigation is the preparedness of the actor to be necessarily and physically handled as the operator fits the suit and then applies the marker set to the actor's frame. The location of the markers, in this study an adaption of the standard configuration in bipedal optical motion capture, is adjusted based on the individual location of major skeletal joints on the performer. The operator places the markers on the actor, and in the identification of the positions the actor is often squeezed, prodded and manipulated so that the markers are evenly and precisely placed on particular skeletal positions.[26] A bond inevitably forms between operator and actor at this early stage. This bond facilitates navigation. Traditionally, the performer is treated as an object to be introduced as an asset in the operator's 3D environment from the outset. To challenge this paradigm, the operator (Daniel Skovli, a constant, or invariant, for

[26] The first time an actor puts on the suit, (noting that the suit is composed of a revealing mix of lycra and double stretch Velcro) can lead to self consciousness and for this reason mirrors are removed from the dressing area. The only mirror that the performer should interact with during a motion capture session is the feedback loop of their performance on a screen

the three workshop cycles) is instructed to undertake an active approach to the induction of the performer(s) by engaging the performer in a conversation around an explanation of the process of the marking up (applying of the markers to the suit) and general function of the marker set from the operator's perspective. This is undertaken while the performer is being prepared, and provides an environmental connection between performer and operator. This leads the actor into the beginnings of an afforded relationship with the operator, and this is significant, as the actor in the suiting up phase is generally placed in a position of environmental vulnerability. This approach to the suiting up phase contributes to the essential alliance necessary between the operator of the device and the performer for performance capture to occur. The intimate relationship established at this stage of initiation sets the scene for the remainder of the capture session.

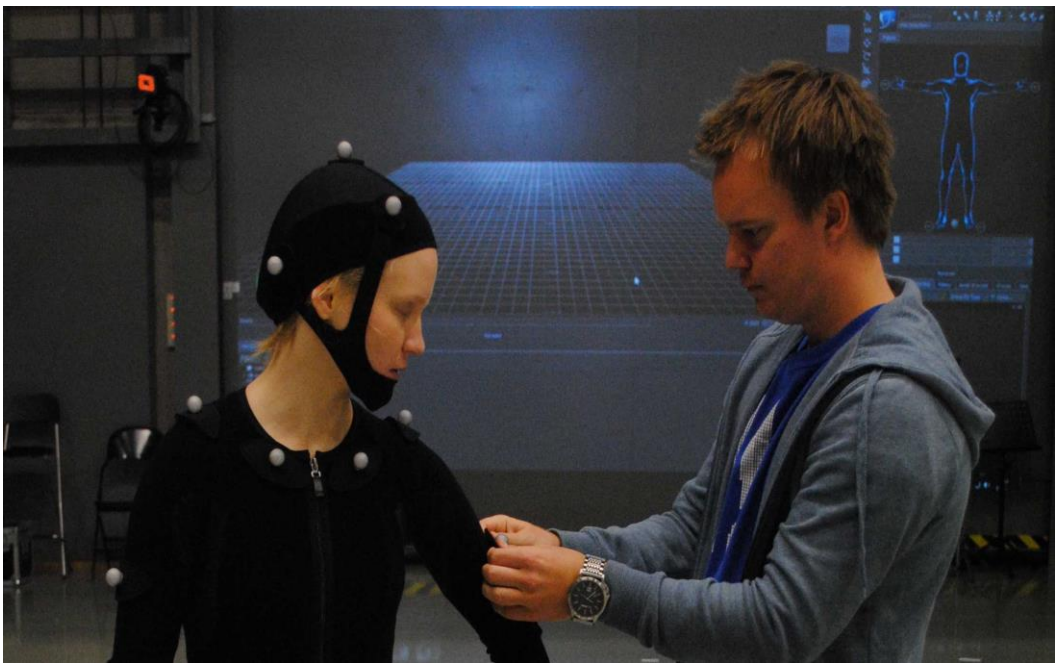

Fig 36: Operator Adjusting Marker (Image M Delbridge 2012)

The next phase of the performer's navigation is concerned with the generation of the template where the performer becomes an object in 3D space. This second phase of initiation sees the operator and performer build on a lasting environmental connection. At this stage the only visual representation the performer has on the screen is a swirling mass of black dots, akin to a swarm of

insects. The performer is asked to locate the centre of the volume and is then instructed to create a T-pose, looking directly at the operator position. The operator demonstrates the physical pose they are looking for and the performer models it. The actor is captured for two seconds and then relaxes as the operator labels and connects the captured marker set, turning the black swirl into an ordered visual representation of colored dots and connected lines, generating an avatar (of sorts) on the screen, of the actor's marker set. The performer observes this process of connection to generate a sense of screen-self and to connect with the work of the operator, who first demonstrates the intermediary position they occupy as the environmental connection between performance and screen space. Once this initial phase is complete the actor is able to connect to the feedback loop projected into the screen space, and this representation of self, generated by the operator, is established as the very centre of the volume, or loci, that places the actor into the 3D workspace.

The avatar forms the first part of the actor's ternary in the workflow, and is only recognised by the system when the actor is at the loci in the initial T-pose position. To respond to this, the operator takes the actor through two more captures, composed of a set series of movements known as ranges of motion (ROM). The operator demonstrates these movements to the actor, and the actor (again in the centre of the environment) follows and copies the movement of the operator. This shared movement sequence between operator and actor is the second of three lasting connections. For a clear demonstration of this process see the T-pose and ROM file in the Illustration of Practice IoP#2 that accompanies Chapter 2.

The data from the ROM files is cleaned (markers renamed when they swap with others) and the actor becomes a solid template able to move around the space and stay labelled as a robust object. The clean data is projected onto the feedback loop so that the performer is able to connect with the workflow of the operator and can more readily perceive their movement, represented visually as

spatial navigation. Following this ROM process, the actor is able to fully explore the capture volume in 3D. It was important to include the performer in the cleaning process to maintain the connection between actor and system. Framing this part of the process for the actor was an integral part of the conceptualisation of the capture cycle.

Navigating the second layer of the animation pipeline; the Pre-visualisation Software Environment and Neutral Actor

The Navigation of the pre-visualisation environment, including the driving of the neutral actor avatar (NAA) is the second stage for the performer. It provides a feedback loop that moves from the abstracted image presented in the templating stage and facilitates the most confronting real time relay of the performer from physical to screen space. Constructing the navigation exercises in this part of the cycle presents the richest opportunity for revealing the experience of working in both physical and screen space, particularly in relation to the performer's response to their driving of the NAA in the virtual.

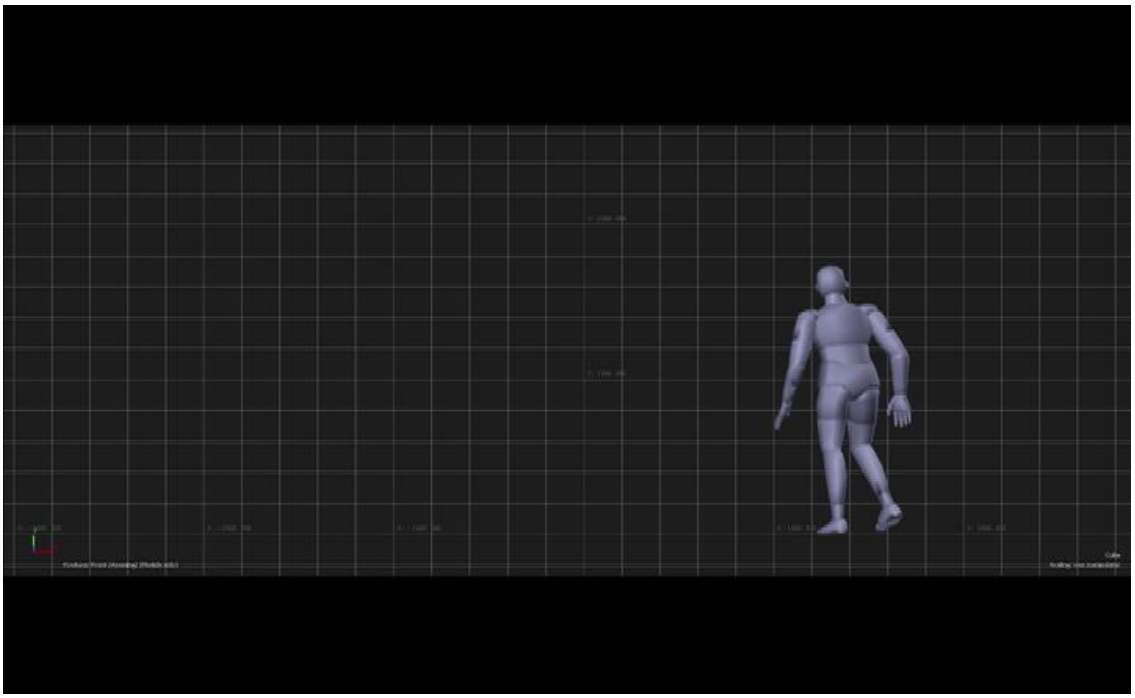

Fig 37: The Neutral Actor Avatar (NAA) in Screen Space (Image M Delbridge 2012)

In the construction of this section of practical experiments I refer to the workspace of the pre-visualisation environment as a neutral space, although in essence it is not the case, and does not seem so to the uninitiated. This notion of neutrality comes from MotionBuilder, the software package used in this study as the pre-visualisation environment. MotionBuilder provides the user with a series of neutral objects like 3D primitives (cubes, spheres, tori) and what is referred to as a neutral actor that input motion can be applied to.[27] The Neutral Actor is referred to as a neutral asset because of its ability to 'take on' the motion capture data of any performance. Once the NAA is allocated input motion (MoCap data) it can be used to drive a characterised avatar like the SAA used in this research.

The screen representation of the motion capture space, particularly when the neutral actor is introduced, begins as an empty workspace that becomes populated as assets are introduced, and so maintains a level of neutrality. Constructing conditions that allow the actor to explore this environment are central to driving the NAA controlled by the actor's marker set. Building from this blank space there are three supplemental stages of navigation the actor encounters. These are detailed in Figure 41, The Neutral Ternary (Delbridge 2012).

Ternaries of Activity

In the *The Triad of Emotion, Action and Reflection* (1994) Chiel Kattenbelt describes the significance of the ternary (or tripartition) as "three concepts which are ideal-typically defined in relation to one another, so that each concept refers to an equivalent aspect, entity or position" (Kattenbelt 1994, p1). Applying Kattenbelt's definition to the environmental aspect of this study illustrates that in order for the director, operator or performer to assert (or define) their position within the MoCap studio they must be defined by the presence of co-inhabitants.

[27] Input motion has been mentioned earlier and is an industry term that refers to the movement of the performer captured and used as data to 'input motion' to a 3D asset (or avatar)

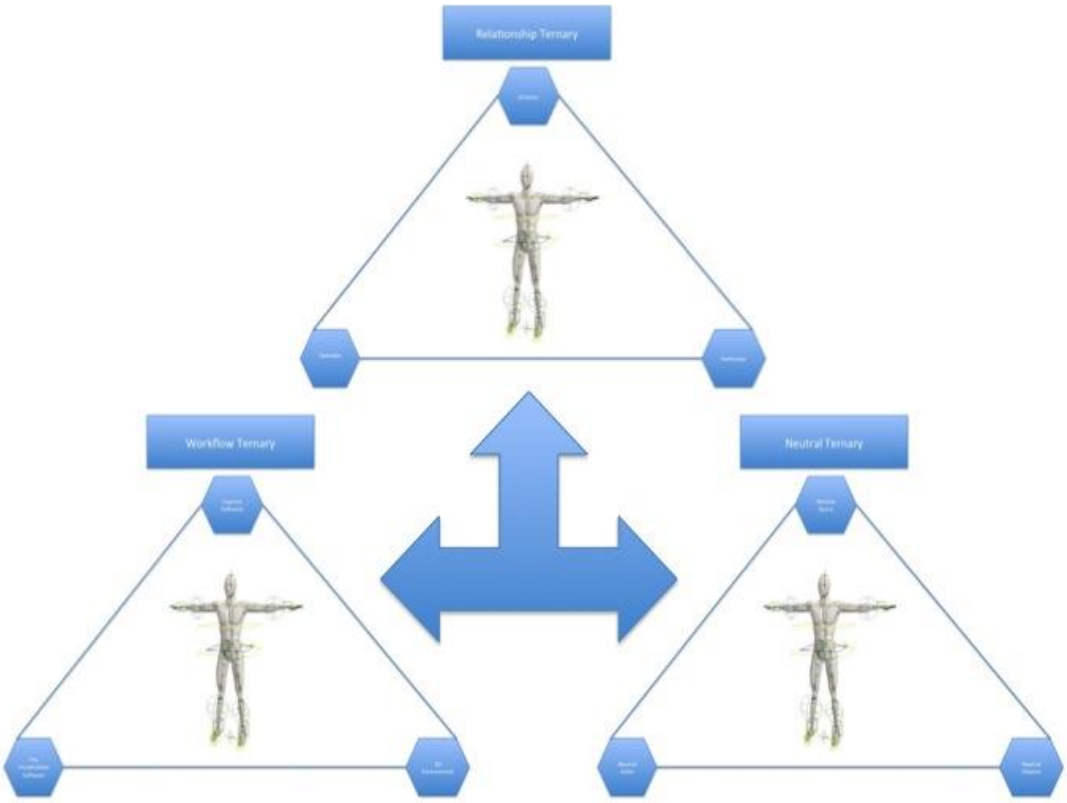

Fig 38: Ternaries of Understanding for performance capture (Image M Delbridge 2013)

A series of ternaries have been devised to configure an understanding of the balanced connection between competing aspects, objects and histories of motion capture. Figure 39: the Relationship Ternary (Delbridge 2012) illustrates three key relationships in MoCap. The director of content is connected to the performer/actor and the operator, and the performer/actor to the operator with equal weight. The development of ternaries of understanding in both MoCap and PeCap form another aspect of this project's contribution to new knowledge.

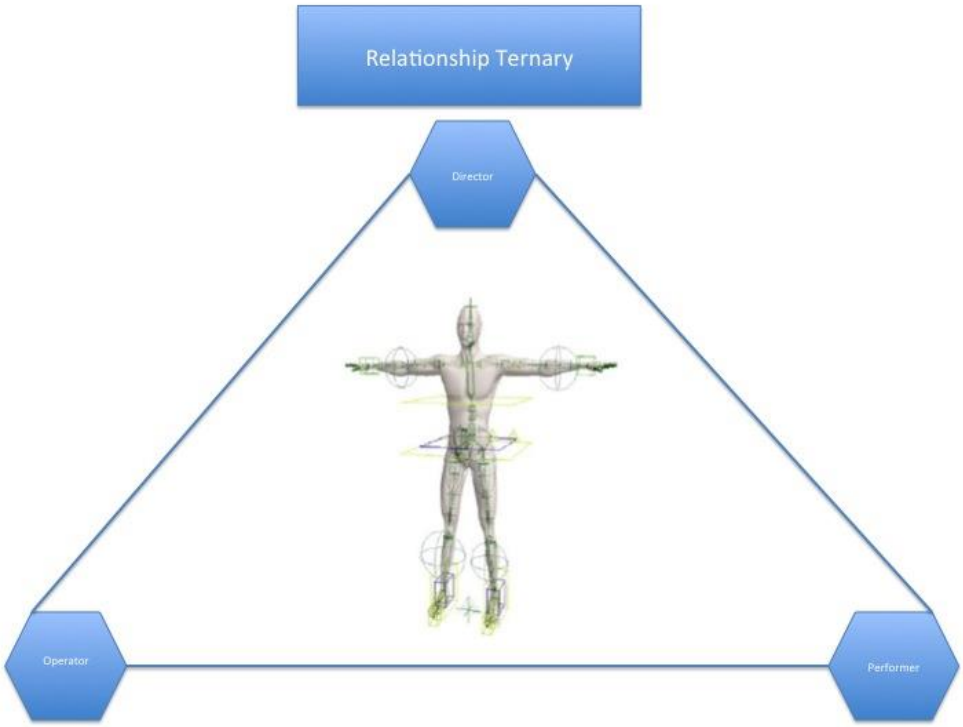

Fig 39: Relationship Ternary (Image M Delbridge 2012)

The Environment of the Workshop Program

In the workshops, performers were tasked with exploring the environment of the studio and the screen in three stages. The first was the introduction of the performer to the motion capture hardware and software – the suit, cameras, and physical capture space, as well as the construction of the performer's template, and the templates interaction with the capture volume; the second, the introduction of the performer to the pre-visualisation environment and the Neutral Avatar the template drives, including the first contact with 3D objects in screen space; the third stage is the introduction of the characterised avatar that the neutral avatar controls, as well as a constructed 3D environment for the characterised actor to perform on. The reconstructed 3D environment in all three workshops was the Rose Theatre. The limitations and challenges of the historical performance environment, alongside the first and second stages, informed a series of exercises undertaken. This is represented in Figure 39: Workflow Ternary (Delbridge 2011).

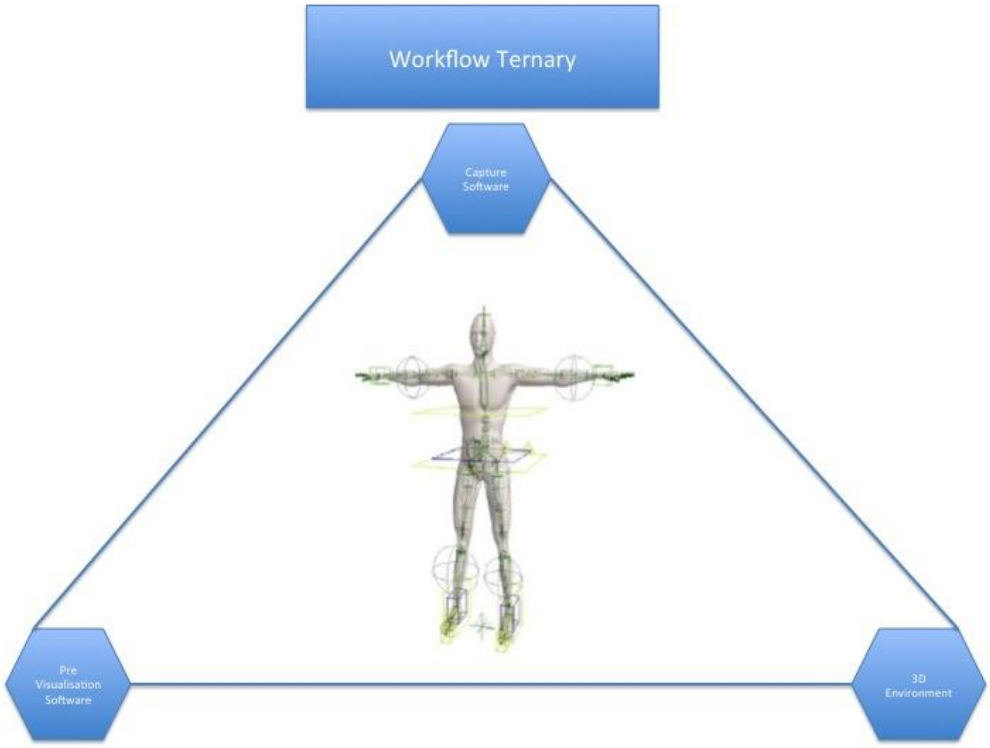

Fig 40: Workflow Ternary (Image M Delbridge 2011)

The Neutral Ternary (Delbridge 2012) asserts that the introduction of the performer to the second stage of capture needs an equal weighting of attention to the tripartite of the neutral actor, neutral objects and neutral space in the pre-visualisation environment. This ternary is constructed sequentially; the performer is introduced to neutral space of the pre-visualisation environment first, then given the NAA to drive before objects are introduced. This forced sense of neutrality for the performer is central to the spatial awareness vital to control of the NAA. The 3D assets introduced in the workspace for the performer to interact with maintain neutrality as simple primitives that belong in the screen environment only and are not replicated in physical space. The introduction of a virtual camera allocated to one of the markers driving the NAA generates a POV of the navigation of the neutral environment. Neutral primitives placed in screen space facilitate a sense of screen-based navigation for the performer. See Figure 41: Neutral Ternary (Delbridge 2011) for more detail.

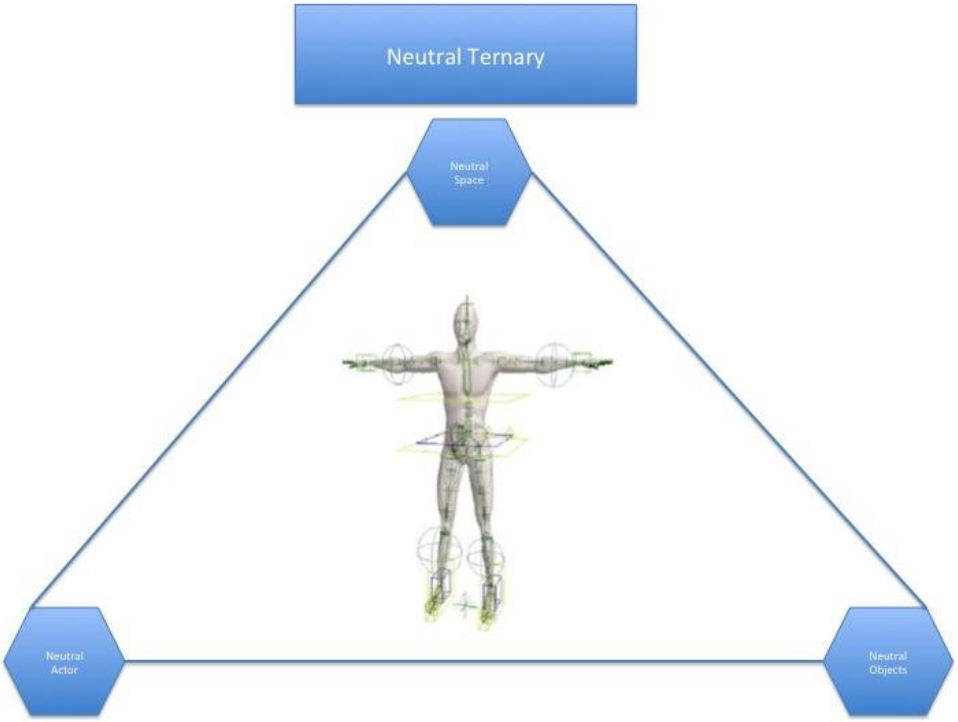

Fig 41: Neutral Ternary (Image M Delbridge 2011)

Over the course of the workshops, navigation exercises facilitated exploration of the neutral stages of the environment. They grew considerably more complex and sophisticated. The illustrations of practice for this chapter better illustrate the development of the navigation exercises that were used throughout the project. The clearest approach for navigating physical to virtual space emerges in the pre-visualisation space (before the introduction of the SAA and Rose Theatre).

The exploration exercises achieved a level of complexity that were enlightening to deliver, and rigorously informed the process for the performer. Two exercises in particular derived demonstrated outcomes and contributions to the field of research from this project. These exercises are called Walking Through and The Donut. The purpose of the navigation exercises is to prepare the actor and director for performance that doesn't rely on the presence of the feedback loop. This process is the beginning of a preparedness to direct performance within *The Omniscient Frame*, or, more precisely, beyond the frame and within the volume. Facilitating the navigation of the neutral virtual space with the actor prepares for

the next stage of the process –the encounter with both the characterised avatar and constructed 3D performance environment.

Walking Through

In Walking Through, the performer navigates between and around three objects placed in screen space in a diagonal line. This forces a memory of a walking pattern. The success of this exercise is concerned with the confidence of the performer to undertake a repeatable number of steps to negotiate objects that only exist in screen space. Initially, the performer relies on vision as a guide before undertaking navigation based on a learned spatial awareness developed from this ambulatory vision. Three objects are virtually placed in the capture volume and can only be viewed through the feedback screen. There are no intentional marks placed within the physical environment (i.e. marks on the floor) to represent the three objects, and the objects are of considerably different scale and shape. The three objects are a tall cylindrical pole, a small stool-size cube, and a sphere and/or a very large torus. The relative scale of the 3D objects is demonstrated in Figure 41: Walking Through (Delbridge 2012) and is shown in detail in IoP#8.

The test for the participant is to see if they can eventually stop relying on the screen as a guide and undertake a simple walking pattern that takes them as close as possible to all three objects without walking through them in screen space. The most revealing aspect of this exercise occurs when the performer begins to use their sense of learned environmental awareness of the physical space. The amount of steps they take in each direction becomes intuitive as they deploy selected invariant objects along the way. These invariances could be a random tape ‘mark’ on the floor, the presence of a join in the tarkett, or position of a camera in the array. These signifiers are immediately endowed with new meaning based on the performers activity in the space (the animals behaviour in the environment). The join in the tarkett becomes more than the surface between two substances and becomes a location on a map signifying the place to turn

around the small cube. When the exercise was undertaken with the screen removed from view there was a noticeable level of anxiety from the performer about walking through the virtual objects. Once the pattern becomes repeatable a connection between virtual and physical space is established.

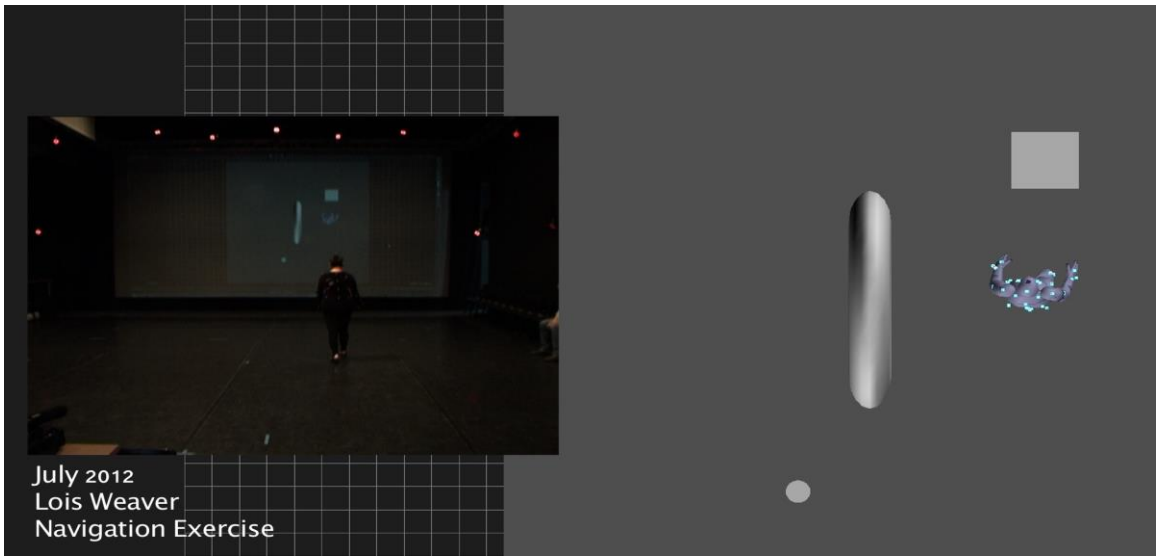

Fig 42: Walking Through (Image M Delbridge 2012)

The Donut

The second exercise, The Donut, extends the complexity of Walking Through by using the 3D torus in the first exercise as an object for the performer to pass through. Initially, using the screen as a guide, the performer has to move through the torus without touching/breaking any of the 3D models. Their connection to the object in virtual space is facilitated through a visually perceived sense of the relative scale the virtualised torus would theoretically occupy in the physical, including a sense of both the girth of the object and the size of the hole in the middle. The only way for the performer to know if they are moving through the object successfully is to use a variety of screen viewpoints that show themselves in relation to different aspects of the torus. The performer guides the operator of the system to change the relative view of the feedback loop to give them the visual representation that allows them to pass through without 'touching' it in the virtualised space. Eventually, the performer is able to pass through the object

without the feedback loop as a guide, relying on a combination of muscle memory and environmental affordances to pass through the centre of the torus without breaking the object in the virtual. This exercise is best understood through a viewing of Lois Weaver in IoP#9.

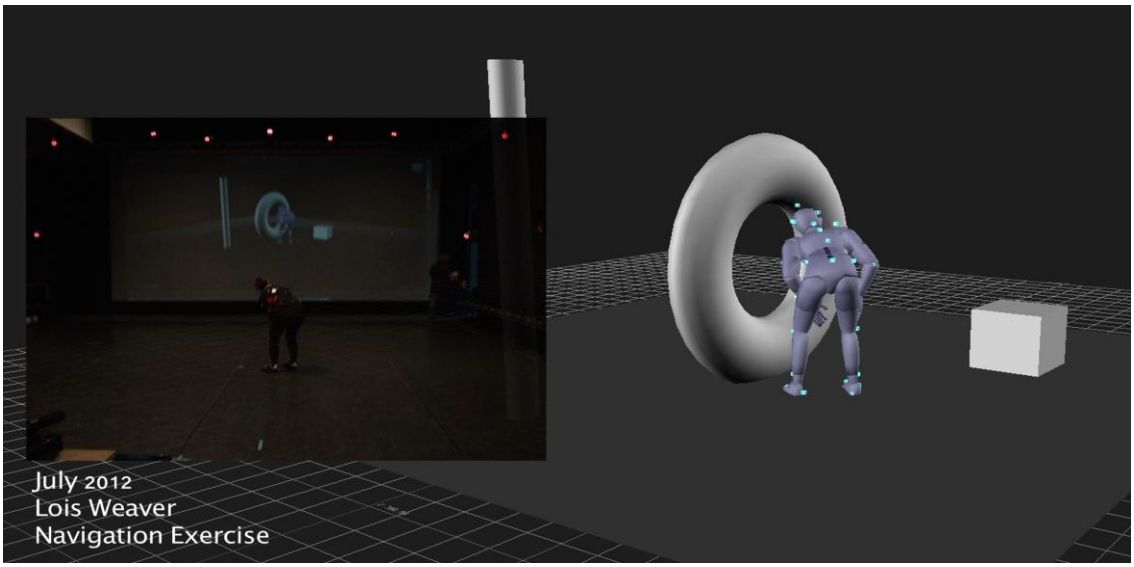

Fig 43: The Donut (Image M Delbridge 2012)

Navigating the Third Layer of the Pipeline; The Characterised Avatar and Modelled Venue

The performers were tasked with driving a shakespearean actor avatar (SAA) in this environment, complete with several unique challenges for them to navigate. These challenges were located as part of the construction of the model and were essential for how the avatar was represented on the stage. The first of which was the SAA not have moving fingers, this provided both opportunities and challenges for the actor. The SAA also did not have controllable features on the face, and in the capture test cycles no face captures were undertaken. The SAA has a ruff around the neck that can be easily broken when the performer moves their chin too close to their chest or tilts their head to an extreme from side-to-side. The SAA has pantaloons and a tunic that balloon out beyond the normal frame of the captured performer and, as such, was very easy for the performer to

literally run their hand through either tunic or pantaloons breaking the SAA (this was discussed briefly earlier in the study).

After each workshop, a clearer understanding of the exploration of 3D space (especially the Rose Theatre) by the performer assisted construction of a structure for negotiating this space. This, in turn, progressed beyond a simple navigation of the 3D screen space and moved to a more rigorous 'testing' of the limitations of the space. This grew out of the second part of the cycle where the backstage area of the Rose Theatre was tested with props and scenic elements, and was further explored by three suited actors streamed into the environment at the same time. Audience interaction in the formal seating of the balconies, for example, provided tests not possible in the single actor scenario(s) deployed in the first cycle with the two individual performers. These audience and seating explorations are best understood by viewing IoP#10.

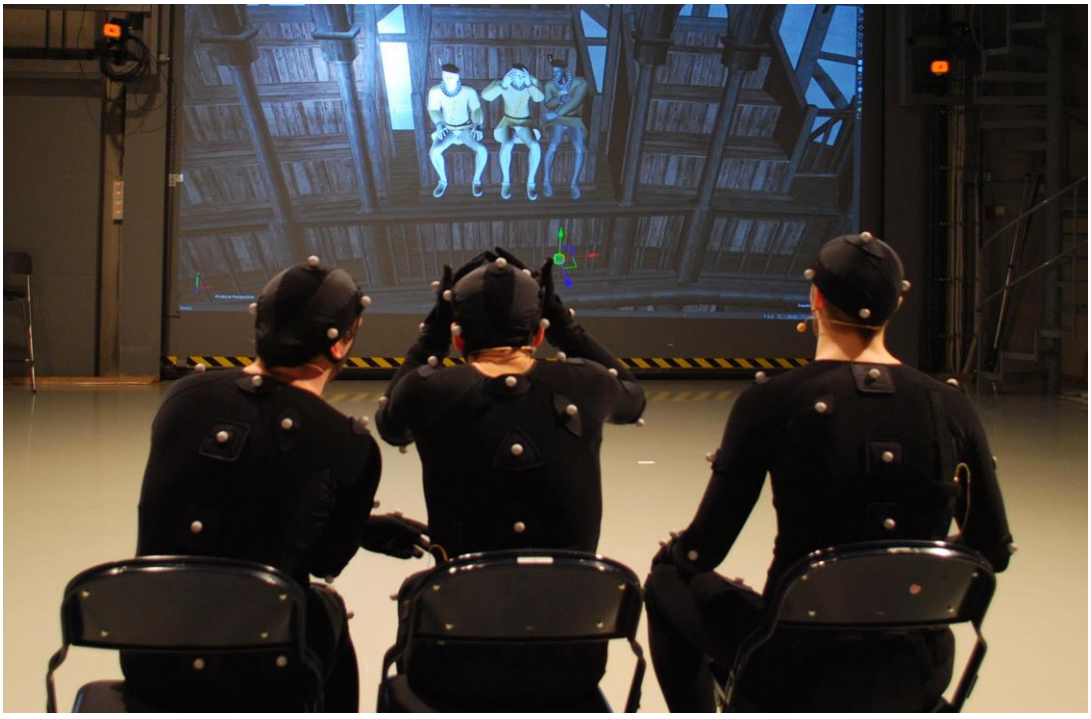

Fig 44: Actors streamed into MotionBuilder environment to test Audience conditions for The Rose Helsinki Workshop (Image M Delbridge 2012)

The performers were tasked with performing to all 5 areas of the Rose Theatre – the groundling area (the floor around the elevated stage), Balconies 1/2/3 + the Lords Box behind the stage. As there were three actors in the Helsinki workshop, we were able to introduce exercises aimed at exploring a performative experience where two participants acted as audience members in the groundling area and one of the performers on the stage. In the actual studio environment all three were performing on the same level, but in the screen space they were placed at different heights. To add further complexity to the navigation, a chest-mounted virtual camera was placed on all three participants, allowing for the performance of each to be viewed from the perspective of the avatar in the virtualised environment.

Along with the exercises introduced here, these navigable spaces, or performance environments, facilitated occupation and habitation. In the next section, James J Gibson's *Ecological Approach to Visual Perception* (1979) is used to consider classification of the visually perceived, identify the time manipulation dilemma as a key consideration in examining questions of landscape, and to discuss navigation in digitally mediated performance and performance capture.

Environmental Discourse

There are two environmental conditions central to an understanding of the translation from physical to screen space that come from this ecological perspective, and both are presented in Gibson's work: "The Animal in The Environment", and, "Surfaces, Mediums and Substances" (1979). The first of Gibson's environmental conditions, "The Animal and the Environment", is known as Gibson's "inseparable pair" (Gibson 1979). In this study, the animal is the performer, the director, the operator or the animator. The environment shifts from physical studio space to captured frame presented on the screen. This notion introduces the vital role of the feedback loop in the capture process, the presence of the screen as a real time connection between physical and virtual

space; and the inseparable imbrication of performance and real time projected feed of movement in a 3D visualisation of space on screen. For Gibson, the words animal and environment are inseparable; each term implies the other: “no animal could exist without an environment surrounding it, equally though not so obvious, with an environment implies an animal to be surrounded’ (Gibson 1979, 9).

We must, then, ask if the environment can have meaning without the presence of the animal. Tim Ingold, both a fan and at times a fierce opponent to Gibson, argues that we “cannot avoid the questions of what an environment is and, more particularly, what, if anything, is special about the environments of those animals we call human beings” (2011, 76). Ingold offers an explanation for the ecological significance of the spaces constructed and used for live performance and performance to be viewed through an unedited human to human interaction like the theatre.[28] The significance here applies to spaces used to capture performance – to the modes of performance for film production, audio production and other digital mediations that involve a machinic or digital interface, like motion capture. These spaces can be framed as potential environments due to their reliance on the presence of the animal (the director, performer, animator and operator) to provide them with meaning. Aspects of the motion capture environment (full of latent potential) compete for meaning and purpose depending on the animal that inhabits it.

Depending on the animal’s role as director, animator, operator or performer, the environment’s significance changes. When there are competing animals present, each brings an individual meaning system to classify the environmental conditions of the studio. This connection, the binaries of the performer and operator in the theatre, or the animator and performer on the screen, or the ternary of the performer, operator and director in the mediated scenario, defines

[28] By Live performance I refer to Auslander’s definition of the live i.e. performance able to be recorded see *Liveness* (1999)

the performance-ready ecology of the environment. It is the combination of the competing meanings that each individual brings to the space that provides the motion capture studio with the ecological classification necessary for performance capture to occur.

Where the theatre actively acknowledges the presence of performer, director, operator and spectator occupying the same space at the time of performance, this performance can be seen to continually address questions of environment. Through mutual occupation, they create, in Gibsonian vernacular, ecological conditions; that is, the condition of the animal surrounded by different inhabitants of the same environment. In film, the place of the animal in the environment has less to do with the audience in the live context (this relationship is formed after an editing process) and is more immediately concerned with mechanical invariants that occupy the landscape and the place and co-function of the director and operator(s).

Ingold questions the value of systemising environmental symbolism:

> The motives and finalities for human action on the environment must lie in what the mind brings to it: in the ideas, concepts and categories of a received cultural tradition. Yet does not the culture with its artefacts and organisational arrangements, and the knowledge of how to apply them, provide human beings with the equipment to draw a livelihood from the world around them?
> (Ingold 2011, 76)

Concepts, categories and cultural traditions form a significant aspect of the uninitiated experience in the capture space. Our meaning-making within this environment is driven by the tradition we bring into the environment and of the tradition of the people who have occupied the environment before we enter.

The second environmental condition is concerned with the place and function of “Surfaces, Mediums and Substances” (Gibson 1979) and the associated

meaning systems attached to these (Ingold, 2011). A knowledge of these encounterable aspects of the motion capture space is central to understanding how an optical MoCap system works. In short, these can be classified as the medium of the physical capture environment, the surfaces of the suit, markers, screen, floor and the substances that evolve through the three stages of capture, from capture software to pre-visualisation workspace to screen-based 3-D venue.

There are particular areas of performance landscapes that can be defined in terms of “Surfaces, Mediums and Substances” (Gibson 1979). Aspects of the motion capture environment can be similarly defined in these terms. Recognising notions of difference in the various forms of performance environment that currently exist and the potential differences in approach demanded from each performance in these spaces is important here. Gibson characterises interfaces in ecological terms; the interface being the area between two substances (or mediums) i.e. earth and water (at the bottom of an ocean), water and sky (at the horizon):

> the surface is where most of the action is, where light is reflected or absorbed…The surface is what touches the animal. The surface is where chemical reaction mostly takes place…the surface is where vibrations of the substances are transmitted into the medium. (Gibson 1979,19)

A surface where two mediums intersect or meet is primarily the point of this interface. For Gibson, the intersection, or meeting, is observable through the presence of light and can also only be completely defined through a moving observation, as opposed to an observation that remains static and framed. This concept of movement is fundamental to the establishment of a thorough visual perception of a landscape, a key factor in the link between the work of Gibson and the initial navigation of vision-based performance capture. In optical motion capture the surface of the marker provides the meeting place between the performer and system. Each camera emits a near infrared lighting source that intersects with a marker. The marker is reflected back. Where two individual

cameras in the array detect the presence of the marker, it's position can be established and movement tracked. When the camera array tracks several markers moving at once, we are able to group the set as an object and construct a template that can be used as input data to drive an asset in 3D screen space. Gibson would regard this tracking process as the transmission of the vibration of substance into the medium (ibid). Figure 45: Surface of Optical Marker with Retro reflective Tape (Delbridge 2013), demonstrates the reflective nature and vibration of the surface of an individual marker commonly used in an optical MoCap system.

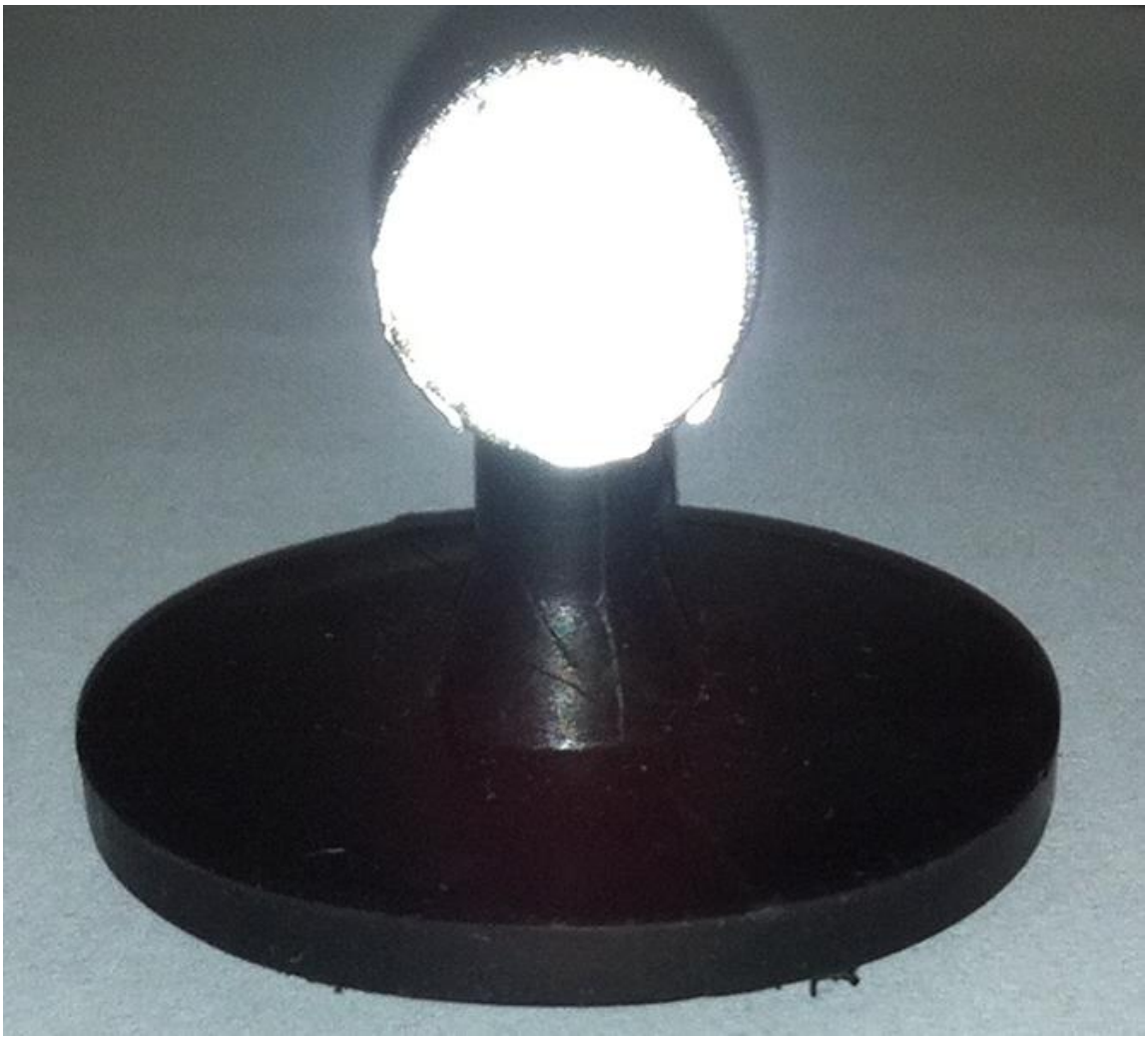

Fig 45: Surface of Optical Marker with Retro reflective Tape (Image M Delbridge 2013)

A substance is the easiest of the three terms to define. Within ecological visualisation, a substance is opaque and reflects light. The substances that exist in performance landscapes can be broadly (and, admittedly, generally) described as lighting fixtures, drapery and screens, floor coverings (including tarkett[29]), portable staging/rostra, as well as other smaller objects used for particular functions like: speakers, props, costumes and cameras. Every substance has a unique surface beyond the definition of the interface, and this surface is subject to change, dependent on the position from which it is perceived. In the motion capture studio an important pairing of substances (with relative surface areas) are the markers (grouped in sets) and the cameras (grouped into an array).

In the ecological frame, a medium is best described as that which facilitates movement through the environment. For different types of 'animals' this can mean different things. For fish, water is a medium; for birds, the air is a medium; in a performance environment, the concept of the medium, or media, is central to the deployment of the ecological terminology. That which facilitates movement through the environment, whether the environment is a theatre, film studio or motion capture lab remains the ground. In the consideration of performance environments existing beyond the general ecological definition, the concept of a medium is also related to a singular technique, or a combined set of techniques, and training. For the performer, this is how they interact with the floor and their capacity to precisely repeat the movement. When we consider that motion capture is primarily concerned with movement, the concept of the ground as a medium and how a performer's technique or training facilitates interaction with the medium is clear.

Further philosophical nuance can be given to Gibson's theories of visual perception via the work of the epistemologist Avrum Stroll. Stroll, a scholar of Gibson's work, suggests Gibson's definitions are contentious, particularly of

[29] Tarkett is a type of flooring commonly installed in rehearsal and performance spaces where there is a significant amount of movement undertaken (like dance studios), it helps to absorb shock to joints and protects the performer from injury.

surface, which he challenges on the existence of the interface. Stroll argues that the horizon, for example, cannot be physically seen, or touched, or cut. “What divides the atmosphere from the water,” he argues, “must be a common boundary, which is neither air nor water”. The boundary is not part of either and must, therefore, be without substance (Stroll 1986, 450). In Stroll’s view, surfaces are “conceptual entities only” (ibid), performance spaces that are virtual in nature. Accurate representations of real space in scale and geometry cannot be physically touched or cut, yet they can definitely be seen. Screen-based representations of the virtual undermine the existence of the conceptual surface. Yet the screen interface between the real and virtual sits at the heart of the influence Gibson’s ideas on environmental navigation can have on discussions of digital performance and PeCap

It is the navigation of the screen-based environment and the classification of the screen as a potential environment in real time motion capture scenarios that places representations on the screen in an environment that is real. The ‘animal’ – the performer, animator, operator or director – occupies and legitimises the landscape. When an actor’s movement is fed live from physical space into 3D space, the interface between the actor and screen remains both the surface of the ground – the real, and the surface of the screen – the virtual.

Uexkull tells us that it is precisely the activity that is undertaken within an environment that gives the environment meaning: “there is meaning in the animals world not because it is capable of fashioning an internal representation of an external state of affairs but because its action in the world is so closely and intimately attuned to its perception” (Uexkull 1992, 320). The ‘animal’ perceives the environment through activity, the performer perceives the studio as an environment for performance, the animator as a site for 3D characters to receive input motion, and the operator as a site that used to be for tracking camera movements (and now tracks the movement of actors with a completely altered

workflow to learn). The director's perception of this environment is fashioned out of their own behaviour and, conversely, by the behaviour of the other inhabitants.

This contradicts Gibson's assertions on affordance, where the environment (and the objects within it) can only be used for one afforded purpose, where "the furnishing of the environment before any creature arrives to fill it – sets the conditions to which any occupant must *adapt*" (Ingold after Gibson, author's emphasis, 2011, 79). The approach proposed in this study supports Ingold's challenge to Gibson, where "the affordances of the environment are there to be discovered and put to use by any creature *equipped* to do so" (ibid, author's emphasis). The infrastructure of the studio at Aalto was reconfigured to match the conditions of the Deakin Motion.Lab because the new occupants in the environment (myself and the operator from Deakin) were equipped to make the changes. That it was set up as a virtual studio before our arrival was of little consequence; its context was changed to suit the activity. "Perception is not a matter of affixing some meaning to the object – of recognising it as one of a certain kind to which certain uses may be attached – but of discovering meaning in the very process of use" (Ingold 2011, 78). The affordance of the object(s) is (are) given meaning by the animals that use them. As highlighted in the previous chapter, the interactions of the inhabitants with the objects that make up the environment are central to the meaning of the space.

It is this common environmental affordance, based on a particular theatrical visual perception of a unit constancy, which makes it possible for an actor or director to locate himself in a performance space they have never visited before. Examples of unfamiliar, but navigable, performative spaces include found performance spaces, like repurposed and converted industrial spaces deployed by performance collectives like Shunt,[30] where the affordance for the director or

[30] The Shunt collective are one of many companies that commonly make works in found spaces. The works they install are site specific (respond to the site where they are made) and commonly require the introduction of standard theatrical equipment to make the found venue function with theatrical convention. See: www.shunt.co.uk

performer is based on the temporarily installed theatrical fittings or the place and existence of a live audience. A performer's learnt environmental perception enables them to reorient successfully, and to appropriately nest themselves within performance environments (either live, mediated or for capture) through an active deployment of these ideas.

Box Camera Exercise

One of the exercises deployed in the workshops was concerned with the function of the virtual camera as an external device to the performer's marker set. It assisted an understanding of what vision and movement means in the virtual. The virtual camera is a viewing frame that exists in screen space and is attached (virtually) to an object in physical space. This can be described as the relationship between either an individual marker (that is part of the performers marker set) or a rigid object (a group of markers assigned object status in the capture environment) and a virtual camera in screen space. This camera viewpoint will display the point of view within the viewing window of the pre-visualisation software[31] (in the case of the workshops, MotionBuilder) of the assigned camera that will adjust POV as the marker or rigid object moves around in physical space. A virtual camera box (seen in Figure 46) and marker assigned camera were used in the workshop at Aalto.

Once the object (previously a normal cardboard box) is repurposed in virtual space, as the supplier of a viewing window, the performer's understanding of it is completely transformed. It becomes a viewing window. This reinforces Ingold's view on the inhabitants of environments who find themselves, "in a world cluttered with objects of all sorts, like householders in an attic or actors on a stage set" (Ingold 2011, 78). Technologically charged environments like the MoCap studio and the use of devices like the repurposed box enable a sense of fun within the working space. When used in the studio, the reapplication of the

[31] The software package MotionBuilder was used for its flexibility, speed and cost effectiveness in the workshop cycles. It allows for a screen-based 3D workspace to be generated as pre-visualisation incorporating environments and a stream of MoCap performance.

box to camera facilitates a sense of play, where a traditional camera might intimidate the operator of the camera - a cardboard box can much more simply be tossed around. Theatre has contributed to a contemporary understanding of the repurposing of objects in performance. This exercise, influenced by my own practice, provides a meaningful connection to an accepted sign system, where theatre transforms staged localities from place to space.

The images in Figure 46: Box Camera Exercise Aalto (Delbridge 2012) illustrates the exercise. The first image highlights the box, the second image shows a performer (not markered) acting as a camera man, and the third image offers the view of the virtual camera on screen.

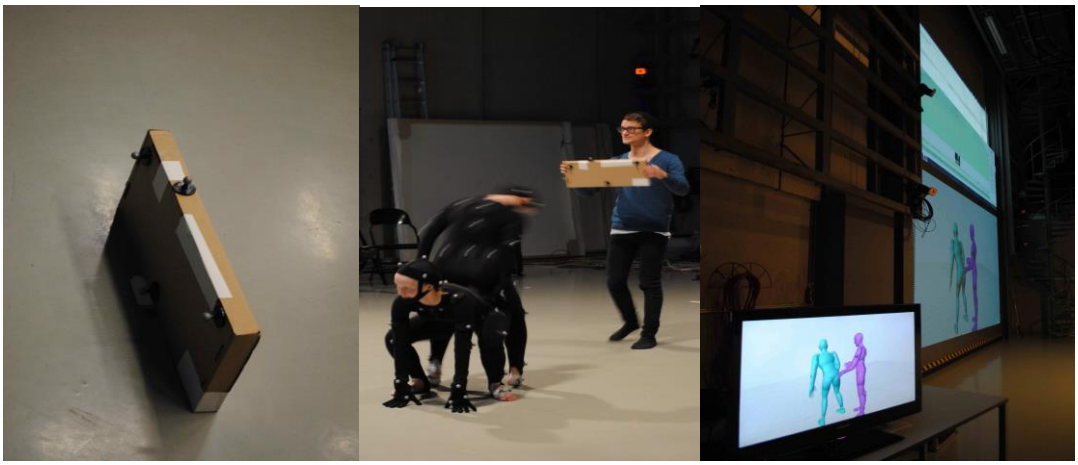

Fig 46: Box Camera Exercise Aalto (Image M Delbridge 2012)

The successful repurposing of objects in the theatre, as applied in the “Box Camera” exercise described above in PeCap, are related to how we treat vision in performance. The work of Gibson is centred on the manipulation of vision and its place as a vital aspect of environmental navigation.

On Vision

For Gibson, the conventional scientific approach to visual perception reduces images to “flattened out objects”(Gibson 1979, 119). Gibson argues that images cannot be seen, the concept of the snapshot is a human construct influenced by

a complicated history of optical studies. Notions of snapshot vision, or the momentary exposure of a stimulus or pattern to the eye, or the scanning of a pattern by the eye, assumes the eye works like a camera, a camera that remains still within a setting, which it does not. While there may be elements relevant in broader optic studies, Gibson suggests the visual system is a lot more complex than this: “visual awareness is in fact panoramic and does in fact persist during long acts of locomotion” (Gibson 1979, 1).

What we see, or acknowledge as sight, is best interrogated by the affordances provided within an ecological understanding of the environment. The features of the environment are inferred or learned, and are concerned with modes of movement, memory, recognition, nesting and scale. Gibson links movement to two modes of vision and argues that afforded sight is central to environmental navigation and perception; these two modes are ambient and ambulatory vision. Ambient vision has the viewer scan an environment by moving their head in a stationary position. Ambulatory vision involves the same continuous scan but is undertaken while moving. These are described as normal vision techniques that sit outside of the traditional tests of vision where a subject sits in a chair with a headrest limiting movement. Instead of viewing vision as a series of frames or snapshots in sequence, ambulatory vision provides a visual flow that discards notions of a flat visual field (Gibson 1979).

Within the environment there are objects that move (like other animals) and objects that do not. The objects that do not are what Gibson calls invariant and are used as anchors to establish a particular visual field (Gibson 1979, 19-23). The horizon in particular is an invariant often used as a visual locator. Gibson also refers to the parts of our own body that we can see as we move as invariant, like part of our nose, or our hands, feet and legs that come in and out of sight as we move (this was explored in the Hand Frame exercise in IoP#7). This notion of the invariant in the landscape is also key to an individual’s understanding of personal balance and environmental place, as it is the constant in the occupied

landscape that serves as a marker for defining a sense of place and provides the necessary stillness that is at the heart of providing balance. In motion capture, the relationship with the environment is on the whole less concerned with a capture of framed image or mechanised invariance. Gibson's notion of the invariant is central to the overall integration of supplied movement by the animal that affords the most complete environmental integration. Through motion capture, the movement dilemma associated with visual environmental navigation can be explored and captured, confirming the link between sight and movement as key components of the establishment of the visual.

Scale, Nesting and the Constant Unit Principle

The ecological account of the visual is primarily concerned with what can be seen with the naked eye, and is not a perception enhanced by any mechanical or digital apparatus. It is an environment where ordinary persons act and interact with familiar objects in mind and is subject to the particulars of what Gibson calls ecological nesting and the constant unit (1979, 9-12). It is within similarly applicable landscapes that nesting and unit constancy take the place of tool-based measurement techniques and this is an important contribution to our discussion of the performer, director and, significantly, operator in the environment. Applying Gibson's nesting and constant unit principles, where "canyons are nested within mountains, trees nested within canyons and leaves nested within trees" (Gibson 1979, 9), allows for a relative sense of unit scale to be deployed in MoCap. This sense of scale is embedded with the measurement of the individual components of an environment, where each aspect is afforded an imbued sense of universality applicable to other comparable environments. The actor nested in the space is applicable to Gibson's "tree in the canyon" (ibid), with attributable concepts of relative scale occurring (though preconceived), as described in the unit constant.

This assertion that in the terrestrial environment there is a sense of universal scale and measurement can be applied to the un-navigated performer (for

example, the actor encountering a new performance environment), dependent on how the environment is described and seen. This environment could be a theatre in a foreign country, an exotic outdoor location on a film shoot or a studio environment where movement for cut scenes in video games is created. Gibson's constant unit principle prescribes that a grain of sand, or a pebble, or a boulder, or even a mountain, is more or less recognisable and classifiable anywhere:

> these natural units are not of course perfectly uniform…nevertheless even if their repetition is not metrically regular, it is stochastically regular, that is to say regular in a probabilistic way…. a blade of grass is a blade of grass. (Gibson 1979,10)

This principle, applicable to performance environments, may provide the fundamental solution to navigation and universal classification within the digitally mediated spaces of MoCap.

Gibson provides a focused insight into how we might begin to frame the navigation dilemma for performers in the virtual when suggesting that we might approach a discussion that places performance in the familiar (as opposed to the foreign) and begin to use the ecological as a way defining the 'unnaturalness' of motion capture studios. This approach, however, only goes a small way in unraveling the expectations we might look for from performers placed within these environments.

Conclusion

In the capture studio we are not reliant on the precision of the naked eye. While the inhabitants of the space are necessarily bound by the conditions of what they can see, this vision is enhanced in screen space when the vision is dramatically supplemented by the visualisation capabilities of a MoCap system. In order to rationalise this conceptually, as environmental, we need to undertake a navigation of the space it occupies. It is in the digitally mediated motion capture

scenario, where the relationship with the environment is, on the whole, less concerned with a capture of framed image or mechanised invariance, that an overall integration of supplied movement by the animal affords the most complete environmental integration. Through motion capture, the movement dilemma associated with visual environmental navigation can be explored and captured, confirming the link between sight and movement as key components of the establishment of visual navigation.

Environmental navigation is normally deployed as part of a formal understanding of ecology and nature studies. In this project it is used to acknowledge the location of individuals within the MoCap studio that would not normally find themselves in the same environment. While there are similarities found in the MoCap studio to the infrastructure of theatre and film, the first time a MoCap studio is encountered it will be read by the occupant in a variety of ways, depending on their own experience (as discussed earlier in Chapter 2 Language).

PeCap is an interdisciplinary discourse that must borrow from other fields to construct a theoretical framework that reflects it's unique nature. Our developing understanding of PeCap can only be strengthened through the ongoing contribution of areas from outside of its direct influence. The presence of the competing discourse in this understanding is simply another 'animal in the environment' and central to the nature of performance capture

Findings and the Future of Performance Capture

The Future of Performance Capture

The outcomes of this study contribute to deepening our current understanding of performance capture, developing the first academically rigorous discourse around the practice and establishing a foundation for its future. Drawn from the three practical workshop cycles and the five domains of understanding, these outcomes are, in the main: the identification of significant terms central to the disciplines of motion and performance capture; the development of a range of practical exercises; and the development of a historical and theoretical discourse. Together these outcomes contribute to the development of a new approach to performance in both physical and virtual space. Other supplemental discoveries made through the study are highlighted around these core outcomes. The isolation of physical, historical, and theoretical perspectives determines an expanded understanding of the field of performance capture.

In reconceptualising key elements of the organisational and physical structures formally used in MoCap, this study has demonstrated that discourses from different fields reveal themselves in a MoCap studio. To allow for clarity in communication between the actor, director and operator, this research has synthesised common terms and initiated the beginnings of a hybrid language, the language of performance capture. Terms in this hybrid language use elements from the discourses of animation, theatre, film and MoCap. This study sets fresh challenges for spatial theory, and significantly contributes to an understanding of the binary of physical and virtual space in performance. It advocates a tool-centred approach to analysing operation, direction and performance in MoCap as necessary steps in this transformation. It identifies performance capture as a complex ecology, one that has evolved alongside other performance ecologies, live and for reproduction. In addition, this study defines and deploys a new conceptual understanding for the encapsulation of the framing potential of performance captured in a volume, called *The Omniscient Frame* (Delbridge 2012).

I have collated the findings from this study under the three sub questions discussed in the introduction:

> How effective are the standard processes for capturing performance and is the current workflow ideal? How can it be improved? Can it be better?
>
> What domains of understanding contribute to a new approach to performance in both physical and virtual space?
>
> What historical, practical and theoretical perspectives can serve to account for and expand our understandings of the field of performance capture?

How effective are the standard processes for capturing performance and is the current workflow ideal? How can it be improved? Can it be better?

Transforming Industry Practice

The study's central argument is that successful performance capture must privilege the act of performance equally with the efficiencies using a MoCap system provides. Into the future, such an approach has an arguably limitless potential to transform the quality of the document generated by the MoCap system.

This study challenges the economic efficiencies that dominate the current industry approach to capturing performance using MoCap. Prior to this research, many of the workflow processes were developed to minimise costs and maximise efficiencies. It is not surprising that performance quality has been compromised as a result. This research asserts that while there will always be an economic imperative, a more holistic approach can improve the capture of performance without significant change to cost or efficiency. This revised approach can, and will, increase the quality of the data, improve performance through better

informed direction, continue to deliver sought after economic advantages, and generally maximise the benefits of using MoCap in the generation of performance.

The preservation of the ‘live’ is only possible through the capture of the aura of performance (Benjamin 1936). This study asserts that, for the most part, this is lost when the recording device is simply turned on. Operating, directing and performing for PeCap is a technological act that demands a technological approach to the generation of performance. Performance capture has shifted industry understanding of ‘performance’. It no longer exists outside of, or separate from, the device.

The performer is an integral component *of* the system. The performer is an integral component *of* the device. As such, their capture is an act that reshapes our understanding of performance as it is constructed for, in alignment with, and seen and recorded through, devices. When performance is captured in the MoCap system, it is transferred into data and becomes a part of a coded virtual environment recreated in screen space. The common workflow privileges the processes involved post performance, after data/code has been generated. PeCap demands that while this aspect is vital and should be offered the requisite weight, emphasis should also be placed in the act of performance, as the data or codified document is generated. This research challenges the standard workflow employed in most commercial studios, where the recorded or captured performance is refined in postproduction. In the foreseeable future, when PeCap becomes a common and accepted practice across our institutions and industry, the performance that is captured will not need to be ‘fixed’ post capture. It will exist as a single take, exact record of what was captured; unedited and streamed real time as a footprint recording of performance (Mulvey 2006). In order for this to occur our sense of operation, performance and direction requires a repurposed approach. This technological approach appears to be incongruous with the making of performance, how it is formally taught in our institutions and

subsequently generated on the stage or the film studio. This includes significant change in the way operators, directors and performers are trained in our institutions into the future.

Specific PeCap Exercises

To counter the implied requirement for large scale re-training or fundamental changes to the training process in the future, the exercises devised in this research are foundational in nature and improve capture practice and the performative experience. These exercises prepare performers, directors and operators to respond to *The Omniscient Frame.*

The Omniscient Frame stands as a fundamental reconceptualisation of the captured frame and provides the most appropriate mode to date for describing and visualising performance captured within a volume. Its identified presence as a primary feature of the capture space determines that a distinct and rigorous discipline of direction and performance is necessary. The series of exercises, devised and tested in the practical workshops of this study, enable a structured relationship to be formed between performer, director, operator, and *The Omniscient Frame*. These exercise are described in the relevant chapters in this document and highlighted in the appropriate Illustrations of Practice. They are: *The Single Camera Exercise*, where a virtual camera is located within the marker set of a performer to generate a POV of themselves in virtual space; *The Box Camera Exercise*, which enables a second performer (or director) to enter the capture volume and generate an external POV that can track the markered performer; *The Hand Frame Exercise*, which introduces the performer's hands in the viewing window to connect the physical to the virtualised; *The Multi Camera Exercise*, which places a virtual camera within multiple performers' marker sets and streams these perspectives into the pre-visualisation environment; *The Walking Through Exercise*, where the navigation between and around neutral objects in screen space forces a memory of the frame that is bound to physical

space; and *The Donut Exercise*, where the performer occupies both the physical and the screen in a sophisticated mode of muscle memory.

These exercises establish the basis of a working methodology to enable creatives to explore the potential of PeCap as a learnable mode of generating performance through use of a MoCap system. As PeCap becomes more formalised, it will require a set series of training exercises that will inevitably transform as they respond to the demands of technological changes in MoCap. The exercises devised in this study are foundational and introductory in nature, and primed for future development.

What domains of understanding contribute to a new approach to performance in both physical and virtual space?

This study has identified five domains of understanding essential in the classification and development of PeCap as a developing mode of performance in the twenty-first century. The isolation of these domains presents a foundation for the discourse of PeCap to build upon. They are by no means exhaustive, but they constitute a substantial academic framework from which to articulate the beginnings of this new field of practice

The *Infrastructure* domain analyses of the physical properties of the space, equipment and personnel normally found in a MoCap studio. The isolation of seven common infrastructural capabilities necessary to undertake optical motion capture is a significant contribution to the knowledge of PeCap. The camera array, workstations, capture space, motion capture suit and marker set, software workflow, personnel and a pre-visualisation set up are crucial aspects of MoCap infrastructure and central to the development of a PeCap workflow. In addition, the isolation and interrogation of the development of devices that have lead to motion capture systems is a significant aspect in this domain of understanding. The discussion on *Infrastructure* outlined the basic principles at the core of motion capture employed in many studios today and challenged how these may

be changed into the future as PeCap becomes a more common practice. It is anticipated that in the future the current emphasis on the tool-centred approach deployed in MoCap will ease, the dominance of the twelve principles of animation as guiding principles to capturing performance will diminish, and the problematic confusion between key roles in the studio will cease as performance is privileged and captured.

The *Language* domain addresses a set of theatrical, filmic, performative and animation discourses that constitute the beginning of a language for PeCap. A collection of terms particular to motion capture that do not come from these traditions has also been isolated. These terms; motion capture, performance capture, marker set, calibration, T-pose, range of motion (ROM), template and volume will become part of the lexicon of performance generally. That they be included in our changing understanding of what performance is and not sit outside of the common knowledge of the actor, operator and director is a major contribution to the field. Additionally, the process of translation that identifies these terms and inserts itself between the competing discourses found in MoCap, is of similar significance. As our understanding of PeCap expands to incorporate the technological conditions of the stage, film and animation, it is able to facilitate this alignment and translation. This impacts on, and adds to, the ongoing development of the language of performance, and sets the foundation for a new and emergent performative language: the language of performance capture.

The *Space and Framing* domain investigates the duality of physical and virtual space in performance. It has confirmed that only through the act of practice can the duality of these spaces be sufficiently explored, and when underpinned with relevant theoretical models, this new view of practice enhances PeCap's ability to interrogate visualised 3D for the screen. The spatial exercises undertaken to explore this phenomenon have made a foundational contribution to the essential study of space in PeCap. *Space and Framing* deepens an understanding,

grounded in practice, for three vital aspects of spatial discourse in performance capture; *The Omniscient Frame*, the capture volume, and the translation of performance from the physical to the screen. This presents a major contribution to the development of a future approach to discussing space in performance generally and offers opportunities for future study into the relationship between real time feedback systems and the preparation of performers in both industry and training institutions.

The domain of *Tool Use and Time* illuminates the complex connection between the actor, avatar and operator in the capture of performance using MoCap. The connection between the performer, operator and *techné* at the core of this performance enhances the tool-centred practice of performing and operating for performance capture. This finding makes a significant contribution to the practice and philosophical discourse of contemporary performance, and offers an essential insight into the intervention between director, operator, actor and the systems central to the practice of PeCap. This intervention centres on the aura of performance, which can now be preserved with the capture of movement. The link between what is lost from the live in early film and what is found in PeCap revolutionises the preservation of liveness in the documentation of performance, now and into the future. This opens the door for more practical studies to be undertaken in this contentious area of research. The third major finding from this domain is concerned with the role of the operator in the capture of performance. The description of the operator's relationship to both machines and performance in Pirandello's *Shoot! (Si Gara!)* (1926) provides a telling description of tremendous use to the analysis of operating a MoCap system. This connection between operator, device and performer is vital to the development of an approach to PeCap at the core of this study, thus challenging how we consider the operator's role into the future.

The *Environmental Navigation* domain establishes a clearly defined set of principles associated with the navigation of capture volumes (as opposed to

performance spaces) as a necessary aspect of the distinction between MoCap and PeCap. Framing the motion capture space as an ecology places focus on habitation of MoCap studios by individuals with widely varied experiences. It suggests that one of the more effective ways to navigate the MoCap space is through visual perception. It illustrates a series of exercises developed to foster the visual navigation of performers through the environmental conditions of the capture process and suggests that a series of terms, particular to environmental psychology, be adopted into the developing lexicon of PeCap. The terms affordance, invariance, nesting, constant unit principle, surfaces, mediums and substances (in Chapter 5) provide a conceptual frame to determine how visual perception is deployed in PeCap and contribute additional meaning to the development of this form. The deployment of the ecological approach suggests that the MoCap studio has naturally evolved from the infrastructures of our theatrical and filmic history, that a primary aspect of introducing a new mode of performance is environmental, and that navigating performance in virtual space is best understood through practical exercises.

Several perspectives have been used to contextualise and analyse performance capture within this study. They make various contributions to a growing understanding of the place and function of PeCap in contemporary practice. The historical perspectives applied come from photographic, animation, theatre and film history. These histories reinforce the place that PeCap now occupies as an interdisciplinary form ready to make it's own contribution to the history of performance and documentation. This is a major finding from this study. A new and important field of performance has been located within a historical timeline and now assumes its place as a legitimate interdisciplinary performance practice.

What historical, practical and theoretical perspectives can serve to account for and expand our understandings of the field of Performance Capture?

PeCap is a set of practical actions which are necessarily informed by historical

and theoretical perspectives. The isolation of these perspectives represents a major finding from this study and sets a foundation for further work to be undertaken into the future. I contend that the three most important aspects of these contributions are aligned to this notion.

They are as follows:

The contribution spatial discourse makes in revitalising an approach to framing, particularly in terms of the replication of the physical to visualised 3D for the screen. These are presented at their strongest through the connections established between Schlemmer's laws of cubical space, native costuming, the camera array and the animated character in 3D space. When these are placed alongside Lefebvre's outlived space, and Bachelard's 'roundness' they become primary contributors in the construction of a philosophical discourse for PeCap.

The second contribution comes from Pirandello's work of fiction, *Shoot! (Si Gara!)* (1926), which contributes an understanding of performing, directing and operating devices that capture performance in a way that instantly connects to the recording afforded by a MoCap system. I suggest the work of Pirandello will remain a major contributor to any future studies of PeCap, and deserves a more prominent place in the canon of performance studies generally.

The final contribution comes from ecological psychology, in particular James J Gibson (1979). The application of Gibson as a contributor to the scholarship of mediated performance and the development of performance capture occurs here for the first time. This ecological perspective is especially important as it strengthens interdisciplinary understandings of performance capture. An introduction of terms drawn from ecological psychology facilitates the ongoing integration of different traditions into the capture environment and, as previously mentioned, contributes to the language of PeCap.

Conclusion

This thesis is a foundational study for a new field of performance. This dissertation has shared the story of my research journey through the practical fields of motion capture, animation, film, theatre and performance and defines the modes of practice at the heart of performance capture. The practice-based research methodology I adopted has illuminated the process of capturing performance in a MoCap studio and has enabled an exploration of, and reflection on, these experiences through the written exegesis and the edited illustrations of practice. The influence that this research may have on the methods of capturing performance using MoCap remains to be seen. This study has developed and documented a set of first principles that help to shape and define PeCap. It is to be hoped that from these principles the field will grow and develop not only as a professional activity in MoCap studios around the world, but as a new disciplinary regime with it's own historical, social and epistemological foundations.

Illustrations of Practice

IoP#1 MoCap Introduction
http://www.youtube.com/watch?v=CP6hDeHiDCE

IoP#2 Range of Motion (ROM)
http://www.youtube.com/watch?v=nulfHVOUW_E

IoP#3 Capture Volume
http://www.youtube.com/watch?v=_QTrxT3oNY

IoP#4 Costume Space
http://www.youtube.com/watch?v=wgM4wMoWY_k

IoP#5 Single Camera Exercise
http://www.youtube.com/watch?v=7BPEceyzwEY

IoP#6 Multi Camera Exercise
http://www.youtube.com/watch?v=tRbAVdnQulk

IoP#7 Hand Frame
http://www.youtube.com/watch?v=wuUTBvGHWTw

IoP#8 Walking Through
http://www.youtube.com/watch?v=9LC9a10jeh8

IoP#9 The Donut
http://www.youtube.com/watch?v=vMYrb2pKFfU

IoP#10 Rose Theater Audience
http://www.youtube.com/watch?v=B4ILoMInS2M

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